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The Changing Face of Broadcasting:

Research Proposals for New Broadcast Services

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Abstract

Current broadcasting systems, and to a much greater extent, new digital broadcasting technology and delivery systems currently under development, offer possibilities for a host of new services for the Canadian public. This report examines the trends in new services and the associated enabling technologies, and proposes a number of research projects which the Department of Communications' Broadcast Technology Branch is especially prepared to carry out. One stream of research is aimed at developing and demonstrating two quite different broadcast services, an Advanced Traveller Information System, and a public conferencing/information system called the Canadian Electronic Forum. A second stream of research deals with issues of special concern to broadcasters which appear to be impeding their creation of new services: how to use new technology for more efficient, less costly video production, how to provide greater interactivity in broadcast services, both in the program content and the broadcast infrastructure, and how to provide conditional access to services in a manner which is acceptable to all parties concerned. The report concludes with a number of recommendations to broadcasters on dealing with technological change and the demand for new services.

Volume 1 of the report introduces the topic of new broadcast services, notes the government's role in this research and describes the proposed research plans. The Appendices to this report appear in Volume 2. Appendix A provides a survey of electronic information systems, some of which use broadcast channels in whole or in part for distribution. Appendix B covers current technological trends related to new broadcast services. Appendix C lists the persons interviewed during this study.

Résumé

Les systèmes de radiodiffusion actuels et, dans une plus large mesure, les nouvelles technologies de radiodiffusion et de distribution numériques récemment apparues permettent d'offrir de nouveaux services à la population canadienne. Le présent rapport examine les tendances en matière de nouveaux services ainsi que les technologies clés connexes. Il propose un certain nombre de projets de recherche que la Direction générale de la recherche en technologies de radiodiffusion du ministère des Communications est à même de mener à bien. Un des courants de recherches proposés vise la mise au point et la démonstration de deux services de radiodiffusion distincts : un système de pointe d'information à l'intention des voyageurs et un système de conférence et d'information, le Forum électronique canadien. Un autre courant de recherches traite de problèmes qui intéressent particulièrement les radiodiffuseurs et qui semblent entraver la création de nouveaux services : comment utiliser les nouvelles technologies pour assurer une production de programmes vidéo plus efficace et moins coûteuse; comment assurer une meilleure interaction entre les services de radiodiffusion, tant du point de vue du contenu que du point de vue de l'infrastructure; et comment assurer un accès conditionnel aux services qui soit accepté par tous les intéressés. Le rapport se termine par une série de recommandations aux radiodiffuseurs concernant la façon d'aborder l'évolution technologique et la demande de nouveaux services.

Le volume 1 du rapport traite des nouveaux services de radiodiffusion, souligne le rôle du gouvernement dans la recherche liée à ces services et décrit des projets de recherche. Le volume 2 contient les annexes du rapport. L'annexe A donne un aperçu des systèmes électroniques d'information, dont certains exploitent, en totalité ou en partie, des canaux de radiodiffusion pour fins de distribution. L'annexe B traite de l'évolution de la technologie par rapport à la prestation de nouveaux services de radiodiffusion. L'annexe C dresse la liste des personnes interrogées aux fins de l'étude.

Executive Summary

This report is a response to a request from the Broadcast Technologies Research Advisory Board for a review of what was being termed "New Media" and its relation to broadcasting. There was an understanding among Board members that broadcasting, computing, telecommunications, and publishing were merging, but it was unclear what research should be conducted in the Department of Communications' Broadcast Technologies Research Branch (DGBT) to assist the Department and the broadcasters to prepare for the convergence.

The report is based on information gleaned in the summer of 1991 from conferences, interviews, news reports, and other publications. It defines new broadcast services and other concepts used in the report, describes a research program to be conducted over the next five years by the Broadcast Technologies Research branch, and concludes with some recommendations for broadcasters. Some of the information on which the report is based is summarized in the Appendices.

The report considers New Broadcast Services a more appropriate term than "new media" services. A service is defined as consisting of an application and an infrastructure; a new broadcast service includes point-to-multipoint information distribution for the general public where something is new, either in the infrastructure or the application.

Results of this study indicate that broadcasting, which is a very efficient way of distributing information simultaneously to a large number of people, is being used to provide some new types of interactive services. Interaction may be accomplished either by sending large amounts of information with some local storage, or by providing uplinks from viewers to the source. Where there is an uplink, some use cable, while others use cellular radio or telephone, forming a hybrid system.

There is a wide variety in the existing and potential services and their purposes. There are also a number of problems still to be resolved. The poor quality of most user interfaces make services difficult to use. The chicken and egg problems of an audience not prepared to invest in receivers without services and lack of interest in providing services to the small audience still remains. Many engineering design problems and the ever present social and regulatory issues, are unresolved. Therefore, there is much to be learned from working toward solutions to these problems. Canada has the potential to be at the leading edge in providing new services using broadcast networks.

The Department of Communications , has a mandate to conduct research which ensures that Canada's communications systems evolve in an orderly fashion to meet the needs of all Canadians. Concerning new broadcast services, the Department has a role to play not only in developing a technological base for these new services but also to ensure that the cultural community can continue the development and expression of new Canadian content in the services.

The Broadcast Technologies Research Branch should then conduct research that will meet these two goals of developing a technological base for these new services and ensuring that Canadians can use the technologies to provide Canadian content on the new broadcast services.

While the infrastructures for new broadcast services are developing and many applications are being tested and used, it is still a complex enterprise to establish new broadcast services. It is this complexity and in the necessary integration of the infrastructure and the applications from which many research issues arise.

This study concluded that the application and infrastructure must be studied together. It also concluded that research should investigate specific services by trying to bring new service ideas to fruition and should also investigate some of the issues that keep new services from flourishing.

Two categories of projects are proposed in this research plan: "services research" and "issues research". Services research is ranked higher in its specificity to a particular service and in the requirement for direct involvement with partners. Issues research is not as specific to any one service but applies to several services and requires less direct involvement of partners.

Services research proposes to develop demonstrations of new broadcast services for the Canadian public. In this plan two specific services are proposed as a basis for investigating the process of developing services and the issues that need resolution. These are not the only services that might be tried. Other ideas for services could also be investigated. For example, services in educational, health, or community information might be launched.

These two particular projects were chosen because they are both timely, they each offer real services to the general public, some part of each service could be launched within a short time, the services could each be expanded in future, and DGBT has much of the knowledge required to launch such new services. Each service would require partners to plan and implement it.

The services proposed for research are:

Advanced Traveller Information System (ATIS): ATIS systems are part of the area known as Intelligent Vehicle-Highway Systems (IVHS). Research in ATIS in Canada is timely if begun now. Europe, the United States, and Japan are experimenting with them. Other agencies in Canada are beginning to think about them. Working with partners in various levels of government and in the broadcast industry, it would not take long for DGBT to acquire the available knowledge. DGBT's contribution would include engineering studies related to the application of Digital Audio Broadcasting (DAB) and other communication systems to the IVHS system, as well as research on user interface to information systems in a mobile environment.

The Canadian Electronic Forum (CEF): A national computer-mediated conference system would combine the information processing power of computers with the information dissemination capabilities of the broadcast networks. It would allow Canadians to communicate with each other in a new way, seek information, find outlets for their creativity, and interface more easily with public sector organizations all using the broadcast networks.

The CEF is also timely. While there are a number of computer conference systems available commercially and on educational networks, they are not widely used by the general public. Broadcasters could offer to make these services more widely available. The service could begin quickly with text based initial services. It is likely that the technology for expanding to pictures and sound will be available within a few years. DGBT's contribution would be research on the user interface as well as engineering studies related to the use of the broadcast infrastructure.

Issues research is aimed at solving several problems faced by the broadcast industry that impede their providing new broadcast services. Issues are generally relevant to several services. The study concluded that there are several pressing issues that need resolution before new broadcast services can be implemented in any major way.

Video Production Technologies: Broadcast industries in Canada, including Canadian Broadcasting Corporation (CBC) Television and TVOntario, want technological innovations which will reduce the cost of their productions. DGBT's knowledge of behavioural measurement techniques and of digital computers, multimedia and human factors would be used to identify opportunities to augment the production process. The project outcome would be technologies to facilitate production, and their functional specifications for interested Canadian manufacturers. Better production technologies would assist in preparing both traditional programming and new broadcast services programming.

Interactivity Research: New broadcast services are different primarily because there are increased opportunities to interact with program delivery and content. Already, in some places viewers are using "pay-per-view"(PPV) systems to select and pay for available programs. Soon viewers may be able to request video programs and provide feedback to the broadcaster using some form of uplink. Viewers may also wish to select programs on the basis of content rather than titles. Some services may even permit viewers to query program content. The research will address the best way to accept and respond to such queries. Most of the issues arising from these scenarios can only be addressed by developing or acquiring examples of new media systems in order to gather viewer's reactions.

Conditional Access Broadcast Systems: The methods developed to provide conditional access to services will affect the bandwidth required for a given service. The project will investigate this effect by studying the interaction between number of service-related messages and constraints on the user. The design of secure systems and alternative methods for managing access will be examined in terms of reliability and convenience.

Uplink Studies: For many services only local interaction is needed to select specific information from what is broadcast. In other cases the user must interact with the service provider by means of some kind of uplink. In this area of work some representative candidate services will be identified and implementation tradeoffs will be examined in terms of uplink possibilities and local storage.

The report concludes by presenting a set of recommendations that, if accepted, should put broadcasters in a position to provide new broadcast services within the next few years. The research projects will ensure that the role of the Department of Communications in overseeing the orderly introduction of services is well supported and integrated with the needs of the broadcast industry.

List of Abbreviations

ABSOC	Advanced Broadcast Systems of Canada
ALEX	Bell Canada videotex service
AM	Amplitude Modulation
AMTICS	Advanced Mobile Traffic Information and Communication System (Japan)
ARI	Autofahrer Rundfunk Information, Germany
ATIS	Advanced Traveller Information System
ATMS	Advanced Traffic Management Systems
ATV	Advanced Television
AVCS	Advanced Vehicle Control Systems
BC	British Columbia, Canada
BCIS	Boston Community Information Service
BBC	British Broadcasting Corporation, United Kingdom
BBS	Bulletin Board System
B-ISDN	Broadband Integrated Services Digital Network
CBC	Canadian Broadcasting Corporation, Canada
CCETT	Centre Commun d'Etudes en Téléphonie et Télecommunications
CCIR	International Radio Consultative Committee, a committee of the International Telecommunication Union of the United Nations
CCITT	International Telegraph and Telephone Consultative Committee
CD-ROM	Compact Disk - Read Only Memory
CEF	Canadian Electronic Forum
CHAT	Conversational Hypertext Access Technology
CMC	Computer Mediated Conferencing
CPLPS	Chinese Presentation Level Protocol Syntax (videotex standard)
CRT	Cathode Ray Tube
CRTC	Canadian Radio-Television and Telecommunications Commission
CVO	Commercial Vehicle Operations
DAB	Digital Audio Broadcasting
DBS	Direct Broadcast Satellite
DGBT	Broadcast Technologies Research Branch, Communications Research Centre, Commmunications Canada
DND	Department of National Defence, Government of Canada
DVI	Digital Video Interactive
EBU	European Broadcasting Union
FCC	Federal Communications Commission, United States
FM	Frequency Modulation
FSK	Frequency Shift Keying

GIS	Geographic Information System
GM	General Motors
GTA	Government Telecommunications Agency, Canada
HAIR	Highway Advisory Information Radio
HAR	Highway Advisory Radio
HDTV	High Density Television
IBM	International Business Machine
IEEE	Institute of Electrical and Electronics Engineers
INS	Inertial Navagation System
ISDN	Integrated Services Data Network
ISO	International Standards Organization
IVHS	Intelligent Vehicle Highway System
LAN	Local Area Network
LCD	Liquid Crystal Display
LISB	Leit and Information System Berlin (IVHS field trial system)
MIT	Massachusetts Institute of Technology
MOT	Ministry of Transport, Government of Ontario
MOU	Memorandum of Understanding
MSAT	Mobile Satellite
NAB	National Association of Broadcasters, United States
NABTS	North American Basic Teletext Specifications (the television standard currently used in North America and other countries)
NAPLPS	North American Presentation Level Protocol Syntax (videotex standard)
NRC	National Research Council, Ottawa
NTSC	National Television Systems Committee, the present television standard used in North America
NTT	Nippon Telegraph and Telephone Corporation
OAG	Official Airline Guide
OSI	Open System Interconnection
PAL	Phase Alternation Line, the present television standard used in Germany and other countries
PBS	Public Broadcasting System, United States
PC	Personal Computer
PCN	Personal Communications Network
PEI	Prince Edward Island, Canada
PEN	People's Electronic Network
PPV	Pay-Per-View
PSTN	Public Switched Telephone Network
PTT	Post Telephone and Telegraph

RACS	Road/Automobile Communication System (Japan)
RAM	Random Access Memory
RDS	Radio Data System
RF	Radio Frequency
SAP	Second Audio Program (in NSTC TV stereo sound)
SCA	Subsidiary Communication Authorization
SCMO	Subsidiary Channel Multiplexed Operations
SECAM	Sequential with Memory (Sequentiel Couleur avec Memoire), the present television standard used in France and other countries
SSB	Single Sideband (Amplitude Modulation)
TMC	Traffic Message Channel
UHF	Ultra High Frequency
UK	United Kingdom
US	United States
USA	United States of America
VAP	Videotex Access Point
VBI	Vertical Blanking Interval
VCR	Video Cassette Recorder
VICS	Vehicle Information Communication System
VPL	VPL Research Inc.(manufacturer of Virtual reality hardware)
VSAT	Very Small Aperature Terminal (satellite earth station)
WORM	Write-Once Read Many (optical disk storage technology)

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Volume 1

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1. Introduction

This report was prepared in response to a request from the Broadcast Technologies Advisory Board for an analysis of the implications for broadcasters of the convergence of broadcasting, computing, telecommunications, and publishing.

The objectives of the study were:

- to survey the developments in broadcast and transmission technologies and in multimedia technologies which would have implications for new broadcast services.
- to propose a research plan for the Broadcast Technologies Research Branch (DGBT) that would assist the Department of Communications and the broadcasters to prepare for presenting new broadcast services.
- to make suggestions to broadcasters regarding their entry into new broadcasting technologies.

The background information for this report was obtained in the summer of 1991 from a number of sources, including researchers investigating the new technologies, professionals in various broadcasting and telecommunications companies, conferences, and related publications. A list of organizations and individuals contacted during this study appears in Appendix C.

Section 2 of the report discusses what is meant by new broadcast services, and what types of services are most appropriate for broadcast infrastructures. Section 3 describes the nature of the research that the Department of Communications and the Broadcast Technologies Research Branch can conduct in collaboration with partners to meet the Department's mandate and to assist the broadcast industry. Section 4 describes the two Services Research projects proposed. Section 5 describes four Issues Research projects proposed. Section 6 gives the conclusions of the study including a number of recommendations toward implementing the partnership between the Department and the broadcasters which would put the broadcasters in a position to provide new broadcast services within the next few years.

In Volume 2, Appendix A provides a survey of electronic information systems world wide some of which use broadcasting technologies in whole or in part for transmission. Appendix B focuses on emerging technologies that point to new infrastructures for transmission and for the production of interactive multimedia products. Appendix B also includes a review of "virtual worlds" technology and its implications for future new services. Appendix C lists the persons interviewed during the study.

2. New Broadcast Services

2.1. Definitions

A *service* consists of an application and an infrastructure. An *application* includes some content and its production. An *infrastructure* includes the distribution channels and the technology to transmit and receive the application.

A *broadcast service*, as opposed to other communications services, is a point-to-multipoint information distribution service intended for the general public. Its infrastructure includes transmission channels such as off-air, cable, and satellite. Broadcast services may also have a hybrid infrastructure which includes telecommunications.

A *new broadcast service* includes something new in either the infrastructure or the application. While this is a loose definition, it is difficult to be more precise at present because the technologies are still emerging. The information in new broadcast services can be either analogue or digital in form. There is often some interactivity, but some services are no more interactive than traditional radio and television.

Multimedia in the sense used here means any system that includes more than one of audio, still graphics, animation, still pictures, and full motion video in its presentation to the user. This definition includes television, but not radio, as a multimedia system. In practice, what is currently considered multimedia includes those products or services that use two or more media in an interactive way.

Interactive means that the system responds to the user's commands to change what is presented.

2.2. The Broadcasting Act

For reference, the definitions provided in Bill C-40, The Broadcasting Act, passed by the House of Commons on December 5, 1990, are discussed here. In that Act:

Broadcasting means any transmission of programs, whether or not encrypted, by radio waves or other means of telecommunication for reception by the public by means of broadcasting receiving apparatus, but does not include any such transmission of programs that is made solely for performance or display in a public place;

Encrypted means treated electronically or otherwise for the purpose of preventing intelligible reception;

Program means sounds or visual images, or a combination of sounds and visual images, that are intended to inform, enlighten, or entertain, but does not include visual images, whether or not combined with sounds, that consists predominantly of alphanumeric text;

Radio waves means electromagnetic waves of frequencies lower than 3000 GHz that are propagated in space without artificial guide;

Other means of telecommunication includes wire, visual or other electromagnetic system, or any optical or technical system;

Thus, many of the services described in this report *can* be termed broadcasting services because they are programs (sound and/or visual images) transmitted by radio waves or other means of telecommunication intended for reception by the general public. However, in this Act the term "program" does not include those programs consisting predominantly of alphanumeric text. Many of the new broadcast services do include mostly text at present, although some are including graphics and other visuals. Certainly, images could be part of most new broadcast services.

The Broadcasting Act does not make reference to interactive services, but it does note (Part II, 5.2f), with respect to the powers of the Canadian Radio-Television and Telecommunications Commission (CRTC), that the Canadian broadcasting system should be regulated and supervised in a flexible manner that does not inhibit the development of information technologies and their application, or the delivery of resultant services to Canadians.

These considerations lead to the conclusion that The Broadcasting Act supports the development of new broadcast services, including interactive services, by the broadcast industry.

2.3. Services Appropriate for Broadcast Systems

In the course of preparing this report, many different services were examined, including both broadcast and non-broadcast forms of delivery. The results of this survey appear in the table in Appendix A.

The major strength of broadcasting is that it is a very efficient way of distributing information simultaneously to a large number of people. In its traditional form, broadcasting is a synchronous form of program delivery. In order to avail themselves of the programs, consumers must arrange their activities around the broadcast schedules. However, consumers are discovering the advantages of asynchronous access to information by, for example, time-shifting programs by VCR. In general, access to broadcasted information can be made asynchronous, and hence more convenient, if the consumer has available local storage with sufficient capacity. Although there will always be a need for real-time programming of timely information, an increasing number of services in the future could involve asynchronous access.

In a straightforward asynchronous application, the information is simply programmed by an information provider and broadcasted. The consumer's equipment passively waits for information of interest to be broadcast, and then records it as it becomes available. In more sophisticated applications, the consumer may request that some particular information be queued for broadcast. The latter implies the need for an "uplink" from the user to the source. The uplink may be on the same medium as the broadcast channel, as in a few cable systems, but more commonly it will be on a completely different medium such as a telephone link, thus forming a hybrid system. In either case, the capacity required in the uplink for a given user is usually very small compared to that of the broadcast channel.

The number of applications appropriate for such a hybrid system is really quite large. In fact, even an intensively interactive multimedia application may be tractable, provided that you have a large amount of local storage available. Such storage, in the form of writable/erasable optical disk drives, is now coming on the market. With a wideband broadcast channel and such a drive, entire multimedia databases can be captured for local interaction. For example, the entire contents of a compact disk - read only memory (CD-ROM) can be transmitted over a 4 Mb/s carrier occupying one TV channel (e.g., Videoway) in about 18 minutes. Applications such as multimedia catalogues, travel brochures, real estate listings, publicly-funded courseware, and government information services are a possibility. Other applications, such as computer conferencing systems (see Section 4.2), also fit the model well and do not require large mass storage capabilities. Still others require little or no local storage at all. If the amount of information is relatively small and the bandwidth sufficient that it can be repeated cyclically at a sufficient rate, then transient information can be pulled out of the broadcast stream on demand and give the appearance of asynchronous access.

A major difficulty with delivering interactive services via the broadcast channel is the deficiencies in the user interface. Most of the attempts at delivering information services over cable (e.g., Videoway) have used a handheld remote control as the input device and the TV set as the output device. Both are inadequate for many interesting applications, especially those which are heavily dependent on text display and entry. Another difficulty is that these dedicated systems lack flexibility in terms of data storage capacity and the ability to interface to other systems. In contrast, most general-purpose home computers have superior input/output devices and are more flexible in their capabilities. Perhaps interactive broadcast services would be enhanced by integration of properly equipped personal computers (already a trend in other home entertainment units). An important point is that general-purpose computers are already present in large quantities in homes and their owners represent a large potential audience for broadcast information systems. For example, about 20% of homes in Ontario already have a personal computer.

The question of whether a particular service is appropriate for broadcasting depends to a large extent on how the broadcast infrastructure evolves in the coming years. The impact of other infrastructures, particularly in the telecommunications sphere, will also be of great importance. People's expectations of new services will also be largely shaped by developments in multimedia computing which is now beginning to enter the home market. The trends in these areas are examined in Appendix B.

3. Research Plans for New Broadcast Services

3.1. Role of the Department of Communications

The Department of Communications has a mandate to strengthen the nation through communications and culture. It must ensure that Canada's communications systems evolve in an orderly fashion, while continuing to meet the needs of all Canadians at affordable costs. It also ensures that Canadians have the freedom to choose a wide selection of Canadian cultural products and information services among the broad international choices being carried on our communications systems.

The Strategic Policy Planning workshop held in July 1990 produced a report entitled "Emergence of the New Media: Are Our Policies Adequate?", which noted that the Department has a role to play in developing a technological base upon which to establish and implement the New Media. It went on to say that the Department needs to examine how the New Media can foster attainment of Canadian cultural objectives by ensuring that the cultural community can have access to and take full advantage of this technology, in order to continue the development and expression of new Canadian content.

3.2. Role of the Broadcast Technologies Research Branch

The Broadcast Technologies Research Branch conducts research directed toward meeting the Department's mandate with respect to broadcast technologies. In new broadcast services, the branch must conduct research that will ensure that the technologies are available both to assist in the orderly development of new services and to ensure that Canadian cultural products and information services reach the public.

The Branch addresses this mandate by planning research projects on the basis of several principles:

- The outcome of projects must be useful either to the government, the general public, or to industry. The expected outcome of projects is typically a technology, a system or service concept, or simply expertise available to government and industry.

- Projects are chosen which are complementary. For example, it is expected that any success in speech recognition will provide a superior input method for a natural language interface. The natural language interface, in turn, is used to present multimedia programs which are managed by a multimedia programming system.

- Projects are chosen which contribute to the breadth of our capabilities. Projects which simply require repetition of steps undertaken in a previous successful project are avoided.

- Projects are chosen which will allow development and demonstration of new technologies. There is little sense in demonstrating a technology that is available already from a foreign source. Pre-existing technologies unless they can be substantially improved, will not give Canadian industry a lead over its international competitors.

3.3. Proposed Research Projects in New Broadcast Services

New broadcast services are complex, and this report concludes that the application and the infrastructure must be investigated together. It is no longer desirable to design an infrastructure and allow the market to plan the applications that can be sent over it. The nature of the service will influence the infrastructure design, particularly where a hybrid system is planned. The infrastructure characteristics will also influence what can be presented in the applications. It is not entirely clear where the design process should start. In conducting the proposed research, the process of design of new services should become clearer as the tools necessary for design become available.

What is clear now is that the integration of application and infrastructure raises many research questions. Four categories of questions emerged from the study: engineering, human factors, economic, and social policy issues.

Research projects could focus on studying these questions in isolation from any specific service, however, this report recommends that two categories of research projects be undertaken. First DGBT in cooperation with partners should launch *Services Research* projects which would implement full services for the general public. Services Research would focus on understanding how to implement new services, and what issues of general concern still exist. *Then Issues Research* would investigate particular issues that emerge from the attempts to establish new services. Issues Research would focus on resolving certain problems and providing information which would make it possible to launch a number of new services. These two categories of research are thus complementary.

This report presents proposals in both categories. The Services Research proposals are discussed in Section 4 and the Research Issues Research proposals in Section 5.

Both preceding categories of research will provide us with greater insight into the possibilities for new broadcast services, and help equip us with the tools and expertise to follow new avenues as new technology unfolds. In addition, there is ongoing research in DGBT which investigates human factors and engineering questions not unique to a particular service. Examples include work on a natural language interface for information databases, a simple interface to control Digital Video Interactive (DVI) technology, a limited vocabulary speech recognition interface, a methodology for retrieving visual images from a data base by their visual appearance, and advanced planning for new Digital Audio Broadcasting (DAB) and Advanced Television (ATV) broadcast systems.

4. Services Research

Services Research deals with implementing specific projects that will illuminate the process of implementation and the issues that need resolution.

Two new services are proposed for current research: Intelligent Vehicle Highway Systems and a Canadian Electronic Forum. It is proposed that DGBT take the lead in the development of these two specific projects which will provide new broadcast services for the Canadian public.

These two services were selected because both are timely and could be put into place, at least in initial versions, fairly quickly. In cooperation with partners, they could certainly be launched within 2-5 years. There are extensive possibilities for expansion of these services using new technology for application production and for infrastructure as it develops. Both offer services of real interest to the general public. As well, DGBT has much knowledge to offer in launching both of these services, both in transmission engineering and in human factors design.

As well as engineering and human factors research, which DGBT proposes to do, each service will require economic and social policy analysis. Partners would be required to conduct these latter analyses.

As well as implementing these services for demonstration and proof of concept, this research should provide greater understanding of how to plan and implement new broadcast services which can be applied to other ideas for services as they arise. The research should also indicate whether there are other issues that apply to service implementations generally and that must be resolved before new services can reach their full potential.

Partners would be required both to implement the service and to conduct the economic and policy research. An initial assessment of service feasibility and impact on broadcast infrastructure can be conducted in-house as an initial stage of the project while partners are being sought.

4.1. Intelligent Vehicle-Highway Systems and Broadcasting

4.1.1. Introduction

The latter half of the twentieth century has seen a massive effort to build an infrastructure for surface transportation. With the close of the century, this phase is now giving way to a new phase, that of applying new technology to optimize the use of the infrastructure, with issues such as public safety, pollution control, and energy conservation rising to the fore. A major part of this effort will be in the area known as Intelligent Vehicle-Highway Systems (IVHS).

The future applications of high technology are notoriously hard to predict but there is no doubt whatsoever that IVHS will be an area of great importance. Large well-funded programs have been in place in Europe and Japan for several years and a few IVHS implementations have reached operational status. In North America IVHS development has been slower but this is beginning to change rapidly. A number of demonstration projects have been established and the U.S. Congress has recently approved an expenditure of $250 million per year for five years, beginning in 1992, for IVHS research and development. Another significant development was the formation in 1990 of a formal organization to coordinate IVHS research and development in North America (IVHS America, with headquarters in Washington, D.C.). As stated by this organization, the basic aims of IVHS are "alleviating traffic congestion, reducing accidents, using energy more efficiently, reducing emissions, and enhancing ride-sharing and bus transit."

In Canada IVHS work is in its formative stages. The major players in the public arena are the ministries of transportation in Ontario, Quebec, and British Columbia, and Transport Canada. There are several private companies and consultants active in the field and some associated university research, most notably Queen's University in route guidance algorithms and the University of Calgary in navigation systems. An informal group known as the IVHS Roundtable has been coordinating Canadian activities and it is currently in the process of establishing a more formal organization to oversee IVHS development in Canada.

4.1.2. The Components of IVHS

There are many aspects to IVHS. One breakdown (Jurgen, 1991) distinguishes four broad, interrelated areas:

Advanced Traffic Management Systems (ATMS) monitor traffic conditions and send the data back to a traffic management centre for analysis. The information is used to adjust traffic signals and variable message signs, advise drivers about current and expected conditions, and so on.

Advanced Traveller Information Systems (ATIS), also called Advanced Driver Information Systems or Mobile Information Systems, provide drivers with route selection and guidance, information on services (e.g., gas, restaurants, accommodation, hospitals), and real-time traffic information (via ATMS). Note that although reference is frequently made to "vehicles" and "drivers" in this text, ATIS is also very much applicable to portable systems whose users may be at home, on foot, or using public transit.

Commercial Vehicle Operations (CVO) Systems are similar to ATIS but also include new facets designed to expedite deliveries, improve efficiency of fleet operations, increase safety for handling hazardous cargoes, and so on. The ability to locate and track vehicles in near real-time is an important component of CVO.

Advanced Vehicle Control Systems (AVCS) are the in-vehicle systems which are designed to prevent collisions and otherwise optimize vehicle operations. Autonomous systems such as anti-lock braking are the first developments in this category with the long-range aim being integration with ATMS and partial or full automatic control of vehicles.

Communications links are clearly a key component of IVHS. Information gathered by static sensors and mobile "probe" vehicles must be quickly communicated to the traffic management centre, and traffic advisories along with other pertinent information must be transmitted to IVHS-equipped vehicles without undue delay. The latter is clearly an application for broadcasting, since many vehicles require the same information (or subsets of it) and multiple point-to-point links (e.g., cellular telephone) would be an extremely inefficient means of delivering it. This is particularly true of ATIS and somewhat less true of CVO, where there is a more of a need for communications directed at a particular vehicle.

In general, CVO developments are proceeding at a faster pace than ATIS, which is not at all surprising, given the demonstrable economic payoffs and the relative ease with which a system can be implemented for a small closed user group. The satellite-based Qualcomm OmniTracs system appears to be an early CVO success story and others will follow (Marisat, MSAT (Mobile Satellite)). A Vision 2000 project called the Mobile Vehicle Management System, scheduled to end in mid-1993, will demonstrate a CVO system using the cellular telephone network as the communications link.

4.1.3. Advanced Traveller Information Systems (ATIS)

In this document we focus on ATIS, since it is the IVHS subsystem which is directly related to broadcasting, but the close relationship with the other aspects of IVHS must always be kept in mind. Some very limited ATIS systems are operational, such as the amplitude modulation (AM) broadcast-based Highway Advisory Radio in the US, and the frequency modulation (FM) subcarrier-based Radio Data System Traffic Message Channel in Europe. With regard to the development of ATIS in North America, three stages have been identified :

Information Stage (1990-1995): During the Information Stage, the primary emphasis will be to provide each driver with information to improve individual planning and decision making. Most of the capabilities will rely on the vehicle's own resources and will be independent of any infrastructure. Such features as dead-reckoning navigation systems, on-board information databases, and static route selection fall into this category. With limited support from the infrastructure, real-time traffic incident information could be made available to drivers to assist in personal route planning.

Advisory Stage (1995-2000): The Advisory Stage will supplement the static on-board information with dynamic traffic information collected and transmitted by the infrastructure. This will include traffic link times (the time to traverse various parts of the road network), traffic incidents, weather, and other factors affecting traffic flow. This digital information will be received by the vehicle automatically and used to compute the current optimum routes or filtered for relevance and only selected items presented to the driver. The vehicle will then guide the driver step-by-step over the optimum route, providing critical information as needed.

Coordination Stage (2000-2010): In the Coordination Stage, vehicles and infrastructure will automatically exchange information to optimize the flow and safety of traffic over the entire network. Vehicles will continually report on traffic conditions encountered. The infrastructure will combine this information using predictive data-fusion models to provide coordinated routing and traffic signal control. Individual vehicles requiring emergency assistance can summon the required service (police, medical, mechanical, etc.), which will be automatically routed to the scene. (Rillings and Betsold, 1991).

The time periods shown are meant to roughly represent the time period from commercial introduction to penetration of approximately 10% of the new-car fleet. The authors claim that at the end of the Information Stage a typical ATIS system will have the following features:

- Dead-reckoning map-matching navigation system
- Digital traffic information receiver
- Static route-planning for minimum distance of travel
- Colour video display for maps, traffic information, and route guidance
- Synthesized voice for traffic information and route guidance
- Map database including turn restrictions and freeway signs
- Business directory database integrated with map database
- Electronic vehicle identification for toll debiting
- Digital cellular telephone

The infrastructure required to support this ATIS system is said to consist of the following:

- Traffic Information Centre to collect, format, and transmit traffic information
- Traffic information transmitters
- Organizations to prepare and distribute map and business directory databases
- Agencies to inspect and certify accuracy and currency of databases used for route guidance
- Toll stations equipped to read vehicle identification

The Information Stage of ATIS development will require research and systems analysis on a number of fronts. Of particular concern are the design of the broadcast channel for dissemination of the information, and the human factors issues associated with extracting and presenting relevant information to the user. Issues associated with the broadcast channel include analysis of the channel capacity requirements for ATIS, design of the protocols and associated communications hardware, and compatibility with other broadcast programming. Since they are generally less obvious and less appreciated than the engineering issues, some of the human factors concerns are discussed in more detail in the next section.

4.1.4. The Importance of Human Factors in IVHS

Any IVHS development which does not include human factors research as a key component is doomed to failure. A person's limited capacity to process information as well as the spatial separation of information sources often result in the sequential allocation of attention as priorities change (e.g., Smiley, 1989). For the driver of a vehicle much of the processing capacity is dedicated to operation of the vehicle. Any other tasks performed while driving are likely to interfere with the driving task. In particular, accessing an information system such as ATIS from within a vehicle can easily be so complex that attention is removed too often from the primary task of driving. This is especially likely if interaction with the system is accomplished using the same modalities as the primary task.

Since the main modality for receiving information relevant to driving is vision, visual displays are likely inappropriate for acquiring ATIS information. Also, since the body's extremities are mainly involved in controlling the vehicle, these are likely poor choices for controlling the operation of an ATIS. For example, operating an ATIS keypad manually will result in longer reaction times for the driving task due both to the visual attention paid to the keypad instead of the road and to the time required to move the hand from the keypad to the vehicle controls.

Given the above considerations, a more acceptable means of controlling an ATIS system is by means of voice input. Speech involves motor activity not employed for driving the vehicle and does not require distraction of the visual modality. Further, speech is a highly automatized activity for most people and requires little cognitive effort for planning output representations. Therefore, interference with the driving task would likely be minimal.

ATIS field trials to date have employed only manual input devices such as the keypad, although speech output has been used successfully for presenting information to the driver (Parviainen, 1990; Verwey, 1989). The paucity of voice actuated systems in field trials may be due to several reasons. The first, and most serious problem, is that current recognition systems are not very accurate when environmental conditions are not stable. That is, fluctuating noise arising from the vehicle engine, the wind, in-car radio, or other passengers can easily interfere with the performance of many speech recognizers. Second, most inexpensive speech recognizers require discrete words as input and therefore, prevent an operator from speaking naturally. A third reason may be that most recognizers are speaker-dependent, in that they must be trained to recognize the voice of a particular individual. This is not a problem for applications where the vocabulary is small and where the operator is always the same person. However, even in this case, day-to-day fluctuations in the characteristics of a person's voice can interfere with reliable performance.

Because speech actuation is so desirable in the ATIS environment, the above problems should be addressed. That is, a speech recognizer needs to be developed that is relatively insensitive to variable background noise, that automatically segments words in continuous speech, and that adapts easily to new speakers. The research literature indicates that these specifications may soon be within reach.

Several researchers have proposed methods of reducing background noise before the signal is processed by the speech recognizer. Background noise may be reduced via subtraction of the noise spectrum from the spectrum containing both speech and noise (Boll, 1979). Enhancements to this approach include the addition of "local spectral peak extraction" (Morito and Tabei, 1987), and the use of a neural network to perform the subtraction (of possibly non-linear components) in the cepstral domain on the basis of prior training data (Sorensen, 1991). Another method was described by Tamura (1989), who analyzed a neural network architecture trained to remove noise from speech time domain data. Also, Tsurufuji et al. (1991) described an algorithm for recognizing speech in the presence of interfering output from a car audio system. Finally, Gagnon and McGee (1991) presented a method for improving intelligibility of speech in noise using "analysis-synthesis resonator filterbanks".

Speaker-independent recognition of discrete words from small vocabularies is available in some commercial devices (e.g., Novatel's cellular telephone dialer, Bell Canada's automated collect call handler). Research in our lab is already underway to extend the vocabulary size and to permit speech to be continuous. Recently developed methods to capture the statistical properties of speech sounds are being exploited.

4.1.5. The Prospects for ATIS Introduction in Canada

As in all new information systems, the introduction of ATIS faces the "chicken-and-egg" problem: it is difficult to justify the cost of putting the infrastructure in place if there are few vehicles equipped to make use of it; on the other hand, manufacturers are reluctant to develop the vehicular equipment, and users reluctant to buy it, until the infrastructure is there to support it. Clearly, the initial infrastructure must be adequate to attract a critical mass of users. The challenge will be to provide this at a reasonable cost and to ensure that the cost of the in-vehicle systems do not pose an insurmountable barrier to acceptance of the service. One of the keys to achieving this objective will be to use to the fullest extent possible any infrastructure elements which are already present for other purposes. This would include such things as existing traffic problem reporting systems, digital Geographic Information Systems (GIS) currently under development, and terrestrial broadcasting systems.

The Radio Data System (RDS) system is now widely available in Europe, thanks largely to the fact that, as an FM subcarrier "piggyback" service, it was feasible for broadcasters to provide it at a low incremental cost. The broadcasters see value in it because it provides program-related information which, among other things, allows drivers to automatically stay tuned to the same program as they move in and out of range of different transmitters. The widespread deployment of RDS transmission facilities was sufficient to convince car manufacturers to begin offering RDS-equipped car radios at a reasonably low added cost. RDS is currently under study for North American use; however, it was not designed to be an ATIS system and it offers very little bandwidth (equivalent to a data rate of around 100 b/s) for traffic information. A dedicated FM subcarrier, possibly coexisting with RDS, could provide much more bandwidth for ATIS, perhaps 4800 or 9600 b/s. Even those transmission rates will likely prove to be inadequate for future ATIS needs - this was a conclusion, for example, reached in a recent Transport Canada study (Chandan et al, 1989).

A more intriguing prospect for ATIS is DAB. Judging from the enthusiastic reception it received from the broadcast community during the 1990 demonstrations and evaluation in Canada, DAB could become a reality towards the end of the 1990-1995 ATIS Information Stage, and a long-term demonstration and "test bed" system may be deployed as early as next year. The DAB system would provide a very robust platform for ATIS, with a potential data rate several orders of magnitude beyond that attainable with FM subcarrier. DAB faces its own chicken-and-egg situation in gaining acceptance and a synergy between DAB and ATIS could prove to be highly beneficial in getting both services established. As in the 1990 DAB trials, demonstrations in the field under realistic conditions will be a crucial element in raising awareness and promoting acceptance of IVHS technology. Since IVHS will depend heavily on communications, the Department of Communications has an important stake in participating in its orderly development.

4.1.6. IVHS Project Outline

The object of this project would not be to start a self-contained project in IVHS within DGBT, but rather to participate with partners in the public and private sectors in a joint development. Our role would be dictated by our strengths in communications systems analysis and signal processing related to broadcast channels, and user interface design. The initial steps required in this process are to increase our familiarity with IVHS and meet with some of the players. Some steps have already been taken:

- A literature search has begun, and a good deal of material has been gathered, some of which has been summarized in Sections 4.1 - 4.5.

- Two DGBT staff members attended the Canadian IVHS Seminar in June 1991, which presented a day-long overview of current and future developments in the field.

- A meeting was held with the Ministry of Transportation of Ontario (Transportation Control and Systems Office), which appears to be the major focal point for IVHS work in Canada. They described some of the problems which IVHS development faces and outlined the results of a feasibility study into a portable ATIS system concept ("Travelguide") which they have recently completed. We in turn talked about some of the possibilities for IVHS communications links and described recent work in DAB system development and speech recognition technology. They were very enthusiastic about our potential involvement and collaboration on the Travelguide system and other IVHS projects.

- A meeting was held with Rogers Broadcasting who participated in the 1990 DAB evaluation and are one of the most enthusiastic proponents of early DAB implementation in Canada. They are in the initial planning stages of fielding a large-scale DAB system in Toronto which will serve as a permanent test bed for the development and demonstration of new digital broadcasting services. The notion of a cooperative venture involving use of the system to demonstrate ancillary services such as ATIS was very well received.

- A DGBT staff member attended the Institute of Electrical and Electronics Engineers (IEEE) Vehicle Navigation and Information Systems conference in October, a major international forum for IVHS work (the 1993 conference will be held in Ottawa).

- An initial meeting was held with Transport Canada (Research and Development Directorate, Ottawa) to discuss possible joint projects.

Some of the next steps that need to be taken include:

- Continue the information-gathering activity through literature search and telephone contacts.
- Join IVHS America (initially as an affiliate member), and participate in the formalization of the Canadian IVHS Roundtable.
- Coordinate our activities with IVHS-related work in the Space sector of the Department of Communications (i.e., MSAT).
- Follow up on our initial meetings with the Ontario Ministry of Transport (MOT), Transport Canada, and Rogers Broadcasting with the aim of identifying other partners and clarifying our respective roles in IVHS prototype development and trials. At some point we will need to formalize our participation, perhaps by means of a Memorandum of Understanding (MOU). We must decide whether to participate in the MOT Travelguide project exclusively, or whether to focus on the development of a higher-end ATIS system (it may not be feasible, for example, to use DAB as the broadcast channel for the Travelguide system).

In the longer term, a host of engineering, human factors, policy, and economic issues must be dealt with. Some of these are outlined below.

4.1.7. Engineering Issues

The engineering work by DGBT will focus on the communications links required in the ATIS infrastructure, particularly the broadcast channel. The work required includes the following:

- Examine the relative merits of different approaches to broadcasting data to vehicles, in terms of data rates, robustness, data integrity, receiver cost, interaction and integration with other services, and so on. Determine the communications requirements for various levels of IVHS services and study the tradeoffs associated with broadcast channel bandwidth and on-board data storage.
- Evaluate present and future possibilities for uplinks from the vehicles to the infrastructure (analog and digital cellular telephone, future Personal Communications Network (PCN) implementations, dedicated microwave or infrared links, etc.).
- Obtain more technical information on prototype DAB equipment and study the problems associated with interfacing to ancillary IVHS equipment. Obtain prototype equipment itself for development work and field trials.
- Work with DAB system planners in the Department of Communications (standards, spectrum management) and elsewhere (Advanced Broadcast Systems of Canada (ABSOC), National Association of Broadcasters (NAB), Eureka?) to study deployment issues (wide area versus cellular coverage, hybrid terrestrial/satellite systems, etc.), provision for ancillary data services and related topics.

- Investigate the means by which information relevant to a particular user can be filtered out of the data stream for access by the user. This is a critical area, since the information transmitted by the ATIS system is potentially very diverse (e.g., short-term data on traffic incidents and weather alerts with varying degrees of urgency; longer-term data on road closures, turn restrictions, special lane usage, etc.; graphical data such as maps; Yellow Pages-type directory services; tourist information and so on), and would involve various types of media (text, graphics, still images, audio). Protocols for formatting and tagging data objects must be developed, along with tools for filtering them.

- Participate in the design of the control centre which gathers the information from various sources (traffic management system, police and other safety agencies, Environment Canada, municipalities, tourist bureaus, directory service providers, etc.) and formats it for broadcast. Study the possibilities for direct or indirect user interaction with the centre.

4.1.8. Human Factors Issues

The human factors work will concentrate on the speech interface to the ATIS vehicle installation. The work will proceed on two fronts:

- Investigate approaches for making the performance of an existing speaker-dependent, discrete word recognizer relatively insensitive to changes in background noise. The resulting implementation will be tested in the MOT ATIS demonstration prototype. The demonstration will also require some task analysis for vocabulary design.

- Continue the current work on speaker-independent, continuous speech recognition with the aim of eventual implementation in the ATIS demonstration system. The intention is to permit the operator to carry on a natural language dialogue with a machine intelligence which will communicate with ATIS when necessary, and perform local functions inside the vehicle such as adjusting the radio upon request.

A number of potential partners exist for this project in addition to those mentioned previously.

National Research Council (NRC) has developed an algorithm for speech recognition in helicopter noise (Hunt and Lefebvre, 1989), and is currently helping Marconi Canada and the Neil Squire Foundation exploit the technology in the context of aids for the handicapped. The NRC/Marconi speech recognizer, which uses a recognition algorithm designed to be resistant to noise and spectral tilt, may be an appropriate starting point for this project.

The Canadian Security Establishment of the Department of National Defence (DND) has a continuing interest in speech enhancement, and may support a project to improve the S/N ratio of speech in noise.

The Ergonomics Division of Transport Canada may be interested in collaborative research to test the human factors aspects of the MOT ATIS demonstration.

4.1.9. Policy and Economic Issues

Policy makers in the department must be made aware of the impending arrival of IVHS and its ramifications. Policies will need to be developed regarding spectrum usage for IVHS, standardization of protocols, access to the broadcast channels by information providers, legal implications of using IVHS services, and so on.

In cooperation with the other partners, we will provide input to the requisite economic studies for those areas in which we have expertise (i.e., state of the art in communications, computing and user interface design).

4.2. The Canadian Electronic Forum

4.2.1. Introduction

Communications is at the heart of building a nation and making it strong. If our nation is to survive and prosper, we must overcome the geographical, social and political barriers that separate us, and learn to understand and appreciate one another's problems and aspirations. Ideally, all citizens of the country would have the wherewithal to spend part of their time each year living and working with others across one or more of these barriers, but this is simply impractical. We must use communications to help break down the barriers and build the bridges to greater understanding and cooperation.

Canada has excellent broadcasting, publishing, and telecommunications facilities; yet somehow they have failed us in pulling down the barriers that would let the farmer from the Prairies understand the problems which face the Toronto businessman or the fisherman in the Maritimes. At the heart of this problem is the fact that there are several different types of communications. Existing infrastructures support some types of communication very well, but do a relatively poor job at others. Although there are many avenues available for us to learn about Canadians in other walks of life, they are largely impersonal - they do not permit us to interact with them directly. In the context of nation building, this interaction is vital.

How can the average Canadian make his views known to others across the country, and engage in dialogues with them? When you stop and think about it, you realize that the outlets are few and that those which do exist are very limited in accessibility and scope. Few of us have access to the print media except as consumers. We can, of course, send letters to the editors, but only a small percentage of those get published and only after a delay of ranging from several weeks to many months. This is hardly a suitable medium for a timely exchange of views involving many participants around the country.

Although the publishing industry remains largely inaccessible to the general public, what about the broadcast industry? The main access point of the general public to broadcast media is the radio "open line" shows. These too have many drawbacks, among them:

- Few of the shows have national coverage (CBC Radio's "Cross-country Checkup" is a notable exception).

- Participants are generally constrained to address only those topics selected by the moderator. They usually interact only with the moderator, not with each other.

- Quality of the content tends to be lower than, for example, letters to the editor, because participants must articulate their thoughts in real time. A pause of 30 seconds to gather your thoughts is fine if you are composing on paper or word processor, but is anathema to broadcasters.

- Many people will not participate for various reasons, perhaps because they feel their verbal skills are inadequate, or possibly because they don't like the sound of their own voice!

There have been some attempts to use broadcasting facilities in innovative ways to improve the level of personal interaction. A recent example is the nationally-televised "electronic town-hall meetings" that were a minor part of the Spicer Commission proceedings. As chairman of the CRTC, Mr. Spicer is said to be anxious to see such experiments continue, with the aim of "working closely within the financial realities so that together we can help Canadians understand each other better" (Ottawa Citizen, Sept. 7, 1991, p. B2). In a similar vein, consumer advocate Ralph Nader (Nader, 1990) has called for the formation in the U.S. of an "audience network", which in his words would "give the audience itself a mechanism to develop an organized communication intelligence". His proposal would place an hour of prime time on every broadcast station back in the hands of the public, who do, after all, "own the airwaves".

Although such innovations in broadcast programming (and publishing) are laudable, they are unlikely to bring breakthroughs in interpersonal communications and understanding. It is time to look outside these domains, towards the great advances made in computers and computer networking technology which have taken place in recent years, to find a new means of making progress.

The basic problem with open line shows and similar services which follow the traditional broadcasting model is that they are synchronous. At any given time, exactly one participant has the floor, and all other participants can only listen to that person. If that person adds nothing pertinent to the discussion, everyone's time is wasted for the duration of his speech. Now consider a more asynchronous approach: many people record their comments, at their leisure, and transmit them to the broadcaster. These inputs are then edited into a program and broadcast. On the receive side, participants record the program and play it back at their leisure (and they can fast-forward through the parts which do not interest them). Based on what they hear, they may wish to record new inputs for the next broadcast.

This asynchronous broadcasting paradigm is strongly analogous to the publishing of letters to the editor. Although it has the potential to resolve one major problem with publishing (especially magazine publishing), namely the long time delay between the creation of the input and having it reach the audience, it still has several major faults. The number of participants and topics covered is greatly constrained by the available network bandwidth if it is carried on normal broadcast channels. Although recording the program affords the participant some rudimentary capability to screen the information and skip material which is not of interest, it suffers by comparison to the print media in this regard. What is needed is a new medium which combines the immediacy of broadcasting with the random access virtues of print media, along with some new capabilities made possible by microcomputer technology. This is Computer Mediated Conferencing (CMC).

CMC facilities are frequently found on centralized online services such as Compuserve, and on distributed systems on computer networks, such as Usenet. There are many CMC implementations, each of which has slightly different features, but they share these important attributes:

- Access to the conferences by participants is asynchronous, i.e., each user has the freedom to participate at any time he or she chooses (this is less true of real-time "chat" conference systems like the French Minitel system; however, the system proposed here is not of this type).

- Participants have complete control over the extent to which they contribute to a conference, and such contributions can be entered into the conference completely asynchronously.

- Participants have various software tools available to them to enable them to make the most of their time while accessing conferences. These tools include filters which can be set up to remove information which is not of interest to the user, a means of easily following dialogue threads on a particular topic, a means of obtaining an overview of a large number of messages before selecting those to be read, and so on.

Unlike the telephone system, which offers "one-to-one" (or perhaps "few-to-few") communications, and traditional broadcasting and publishing systems, which offer "few-to-many" communications, CMC systems offer "many-to-many" communications. CMC systems also offer the freedom of being both time- and distance-independent, and their flexibility makes both "broadcasting" to a wide audience and "narrowcasting" (in terms of either special interests or geography) very easy to accomplish. In short, a CMC system is a very attractive medium for holding an "electronic meeting" involving a large number of participants.

4.2.2. The Convergence of Broadcasting and Computer Conferencing

What is the relationship between Computer Mediated Conferencing and broadcasting? Although at first glance the link may appear tenuous, a CMC system is in fact very much a broadcasting system, albeit a slightly nontraditional one. As mentioned previously, a CMC system is a "many-to-many" medium. Consider it from the point of view of an individual participant who is receiving a vast amount of information, collectively generated by the other participants. He or she must select that which is of interest (leaving aside, for now, the question of whether the selection is done locally or remotely). This is akin to having a broadcast receiver which can tune in a huge number of channels, some of which carry programming which has broad general interest, and many of which are narrowcasting to special interest groups. The CMC goes beyond that, however, because all of the programming can be held in storage and can be randomly accessed on demand. To press the analogy a bit further, it is somewhat like having a bank of machines recording every channel (or at least every channel of interest) and cataloguing the programming so that it can easily be accessed later. In addition, the participant may wish to contribute to one or more programs, so there is an uplink channel available for that purpose. The bandwidth required for the uplink, however, is only a tiny fraction of that which is needed for the broadcast link.

4.2.3. Designing a Public Conferencing System

There are several ways of implementing a wide-area CMC. The online services such as Compuserve have a centralized system, in which the conference information resides in one computer (or several tightly-coupled computers). Users connect to the system via telecommunications links to retrieve new conference data and deposit their contributions. They may elect to compose their contributions while online, and to browse through the message base, reading those which appear to be interesting. If the user has only a terminal, this is the only option, but if the user has a computer, he or she can compose messages offline and also choose which messages to download based upon a summary obtained during a previous connection. The cost of both the conferencing service itself and any long-distance telecommunications services used are normally based on connect time, so minimizing connect time is often an important goal. Nevertheless, the connect time to participate in several active conferences will be substantial. Most users will participate in only a few conferences, since it can be a costly proposition to explore new ones.

Distributed CMC systems such as Usenet and FidoNet Echomail work somewhat differently. In this case, many host computers with wide geographic separation are involved, and each one maintains a copy of the full conference database (or at least a substantial subset of it). This has several advantages, among them being the fact that many more users can reach a node of the conferencing network without incurring long-distance telecommunications charges (someone, however, must still pay for the charges involved in the bulk data transfer between the host systems). Since each host computer now serves only a small subset of the total user community, the computing and telecommunications resources required in a host are modest compared to that required in a centralized system. Typically, the centralized systems will use large mainframe computers, whereas the distributed system can run on personal computers (PC).

One significant shortcoming of many distributed systems is the speed with which new messages propagate to all nodes of the system. In a centralized system, a new message entered into the system is available to all participants immediately (i.e., the next time they log in). In the distributed system, the message must pass from node the node, and this transfer typically takes place only at certain times (e.g., late at night to take at advantage of off-peak telephone rates). Even though a node usually feeds data to several other nodes, and the resultant "flooding" speeds up the propagation of new messages through the network, it still can take several days for them to reach all parts of a large conferencing network. This latency can disturb the flow of discussions and cause many duplicate responses to queries to be generated.

In essence, a CMC system user who inputs a message is broadcasting his message to all other users; only those who choose to participate in that conference, of course, will "tune in" the message. If an existing broadcast infrastructure could be used to deliver the message, it could, in principle at least, be delivered simultaneously to all participants, thus minimizing latency problems. Furthermore, users do not have to incur charges for connect time or telecommunications to receive the data. This makes a broadcast channel a very attractive delivery system for CMC. For large-scale CMC systems, one of the most compelling arguments for using broadcasting is the ease with which it scales. The addition of a new user makes no new demands on the delivery infrastructure whatsoever (assuming the user is within range of the delivery system); only a tiny increment to the capacity of the uplink system is needed.

4.2.4. The Virtues of CMC Communications

As a source of information, the worth of a good CMC system is incalculable. Although there are many sources of factual information of the sort that can be found in encyclopedias, for example, most of the information that people seek in their everyday lives is not in this category. In any case, most people are not experts in finding sources of information. A CMC system with conferences available on a diverse set of topics makes it much easier. Howard Rheingold (1991) gives an example:

> By organizing information this way, it is possible for networks of people to serve as informal support systems for one another. If I need help figuring out how to use a new kind of software, or want the titles of books about a field that attracts my attention, I can log onto a conferencing system, look for the appropriate topic, and post a query. Then I can log off, go about my business, and when I check back an hour or a day later, I often find that somebody I've never met has answered my question. A conferencing system that includes a broad base of members with a wide variety of expertise is a 'living database' in which everyone can serve as a librarian and consultant for everyone else.

Aside from being a source of information, a CMC can be a strong social force which serves to unite people over vast distances. Although this is also a role of such national institutions as the CBC, the strong interactive aspects of a CMC allow it to function on a much more personal level. Users of a CMC can form closely-knit "electronic communities", even though most of them will never meet face-to-face. A national CMC could promote Canadian unity through improved interpersonal communications which cuts across geographical and cultural boundaries, and it would be a particular boon to those who are isolated, whether by geography, handicaps, or otherwise. With the participation of different levels of government, it could also serve as a means of disseminating information on government programs, and making those who govern more responsive to their constituents.

Although there are abundant examples available of CMC systems and their ability to provide information and stimulating social interaction, there have been very few instances in which governments were actively involved in the conferences. This is unfortunate, since a CMC could form a very valuable mechanism for acquiring information from government institutions. Consumer advocate Ralph Nader has written: "At the city hall level, one of the biggest barriers to citizens connecting with their local government is that they can't get the information. Not just because of adamant refusal, but also because the material is not put in the shape where it can be promptly retrieved or segregated from material that might invade somebody's privacy" (Nader, 1990). Participation in a CMC would encourage "city hall" to organize the needed information in a way that would allow it to be easily disseminated electronically (note that although the proposed conference system would be national in scope, there could also be individual conferences which are local in nature).

One of the few examples of government involvement in a CMC is in Santa Monica, California, where the City Council established a electronic community bulletin board system (BBS) known as the People's Electronic Network (PEN) in 1989. Accounts were made available to any resident who registered with the city. For those who do not own a suitable computer (or terminal) and modem or cannot use one from their workplace, dozens of public terminals were set up in libraries, schools and city buildings. Like most BBS systems, PEN offers a mixture of read-only information bulletins, private e-mail, and public conferences. Conference topics include "Crimewatch (run by the police department), PENhelp (online hints on how to use the system), Planning (a forum on land use, zoning, and development), Environment (incorporating discussions of air quality, water pollution, and recycling), and Santa Monica (including rent control, neighbourhood organizing, community events, and news of boards and commissions). Social issues are discussed in several additional conferences. Topics include nuclear weapons, drinking and driving, the media, abortion, gun control, foreign policy, health, intergroup relations, Jewish culture, AIDS, human rights, sexism, and racism." (Wittig, 1991).

The PEN experiment has not been an unqualified success (Varley, 1991). Although more than 3,000 people have signed up for accounts on the system, only 500 to 600 different users actually log on each month. Many of these do not take an active part in the conferences, which are dominated by perhaps 50 "hard-core" users. The latter group tends to be composed of articulate individuals with a predilection for verbal jousting. The resulting exchanges apparently hold the interest of the more passive participants, since they keep coming back for more, but it has had the unfortunate effect of driving away many of the politicians and officials who were initially active on the system. In addition to being subjected to online abuse, they felt that they were spending a disproportionate amount of time responding to the demands of a few constituents. Among other things, this points out a problem with open electronic conferences of this sort: you do not know how large your audience is.

The PEN system, which has been termed an experiment in "electronic democracy", remains in operation. Despite its shortcomings, many of its proponents remain enthusiastic about this new line of communication between government and the public. At the very least, it will provide a number of valuable lessons for future designers of public conferencing systems.

CMC technology also has considerable potential for supplementing formal education in the classroom. Although educational organizations have been slow to recognize this potential, there has been significant activity at the grass roots level. Individual teachers have overcome the obstacles (such as the lack of telephone lines into classrooms) and put together conferencing systems linking their classrooms with others in distant locales. One such network is K12Net (Rickard 1991), a loose agglomeration of more than 100 bulletin board systems around the world. Using the popular FidoNet software (more than 10,000 BBS systems active worldwide), the K12Net systems form a distributed CMC system using the "echomail" concept to distribute the conferences from system to system by telephone. Conferences on about thirty topics form the K12Net "curriculum"; most are on specific education areas such as mathematics and French, but there are also some open conferences for free-wheeling discussions. One of the major attractions of this network is the relatively low cost of setting up a node, along with the low administrative overhead involved in becoming a part of it.

In the context of being an electronic meeting, a CMC can have a remarkable liberating effect on the participants, compared to the reticence one often encounters in face-to-face meetings (or, as mentioned previously, in oral media such as open line radio shows). Hugh Kenner (1991) gives a good example:

> Another thing about keyboard-and-screen: It frees up the psyches. At the University of Texas-Austin, I once visited a poetry seminar run by John Slatin. Some 30 students sat around a large room, each at a terminal, exchanging comments on the day's assignment and on one another's comments. Any teacher knows how efforts to cause oral 'discussion' will activate - at most - four articulate people, the rest sitting dumb. But keyboard participation that morning was close to 100 percent. It was eerie; all of them in the same room, looking not at one another but at monitors, and typing things they wouldn't venture to utter. (Later, everyone received a printout of the hour's interactions).

In and out of the classroom, the possibilities for using CMC technology to stimulate the creative process seem virtually unbounded. One final example :

> "What a wonderful learning experience it has been. It has given me a new perspective on learning and learning how to learn. With other writers of the world, we have all responded and contributed to one another. I see this as something that has changed my life. Education shouldn't always be within classroom walls."
>
> This is what one 12th grade student wrote about her English class after telecommunications technology projects had been introduced into the curriculum. Students, teachers, and writers throughout Canada, the U.S., and the world correspond and the students' work is critiqued by the professionals. The "Writers in Electronic Residence" program of the Riverdale Collegiate Institute in Toronto is supported by the College of Education at Simon Fraser University, and forms the basis of these language-based studies.
>
> Students' works, primarily poetry and short fiction, are posted in electronic conference areas established for their use. The students are in control of the media before them and use them to broaden their classroom experiences. The "Electro-Poets" project involved a class in Toronto, one in British Columbia, and a poet also in British Columbia. During this four-month project, over 200 pages of original writing and comments were generated by the students. They readily accepted the telecommunications activities as part of their daily classroom activity. Another project, "New-Voices", involved a poet, a science-fiction writer, and a short-fiction author, and schools in Ontario and British Columbia. A third project, "Wired Writer", connects ten schools and one author from a past project.
>
> These language-based telecommunications projects inspired students to develop language appropriate to the activity, and offered direct and personal access to computer activities that are relevant today. These telecommunications projects increased the students' access to the world and, as a result, brought to the classroom experiences to meet and enhance existing curricular needs. (DISTED, 1990)

There are many other examples of successful CMC applications which could be cited, but this should give some idea of the possibilities. In the project outlined in the next section, we propose to investigate further the use of broadcasting to provide the basis for a Canadian Electronic Forum based on CMC principles.

4.2.5. Canadian Electronic Forum Project Outline

The ultimate goal of this project would be to create a national computer-mediated conferencing facility and to make it accessible to as many citizens of Canada as possible. Distribution of the conferences would be by means of the existing broadcasting infrastructure wherever possible.

During the first stage of the project, the need for such a service and its potential benefits will be explored in more depth. Obstacles will be identified and ways of overcoming them will be studied. If the outcome of the preliminary studies is encouraging, partners will be sought to participate in the design and testing of the system. In addition to other branches of the Department of Communications, potential partners include the Alberta Research Council, who are already engaged in research on CMC systems, and TVOntario, who have a strong interest and some research experience in the educational possibilities of CMC. The second stage of the project would field a small-scale pilot system which would serve as a test bed and demonstration system. The third stage would see the expansion of the system to national coverage.

Some of the issues which would have to be addressed during the first stage of the project are outlined below.

4.2.6. Engineering Issues

The proposed CEF is a hybrid of a number of different technologies. The engineering problems to be dealt with center around the broadcast channel, but also are concerned with questions of how to interface the broadcast subsystem to the other components of the system. The questions that need to be answered through engineering studies include the following:

- What are the basic parameters of the system - potential number of users, bandwidth required in the distribution system, etc. Should the CEF system be centralized or distributed? What are the uplink possibilities and how does this affect the system design?
- Given these parameters, what delivery mechanism, or combination of mechanisms, should be used to broadcast the information (Vertical Blanking Interval (VBI), FM subcarrier, dedicated channel; cable, satellite, etc.)? How can coverage be extended to isolated parts of the country?
- Although the initial system is likely to be text-only, can multimedia conferencing be accommodated in the future? What other types of media are desirable, and what does this imply for system bandwidth and other parameters?
- Which home computer standards should be supported, and how should they be interfaced to the data broadcast? Is a hard disk a prerequisite, and if so, what is the minimum size required? Would it be feasible to produce a special-purpose CEF terminal for home or kiosk use?
- What are the tradeoffs concerning the broadcast bandwidth (data rate) and the length of time a user's computer must be left turned on in order to capture new information? How can multi-tasking be accomplished, so that user can continue to use his computer for other purposes while capturing conference data? Would it be feasible to provide a "black box" separate from the computer to capture, filter and store information?
- Existing CMC protocols and software packages must be examined for suitability for this application, and if necessary, new software must be developed.
- Access control and other security-related issues: what types of access control (e.g., passwords, smart cards) are most suitable, and how can article forgeries and other types of attack on the system be avoided?

4.2.7. Human Factors Issues

For most potential users of the CEF, using a CMC system will be an entirely new experience. Very careful attention must be paid to good human factors design if the system is to be accepted by a wide range of users. Issues for study include:

- What type of user interface is most suitable for both naive users and those who are more computer-literate?
- A national conferencing system which achieves significant penetration could generate enormous amounts of information. Powerful tools must be developed for filtering and presenting this information to users, and these tools must be very easy to use. Testing of the user interface with typical user populations will be extremely important.
- The issue of moderated versus unmoderated conferences must be carefully examined. Lessons learned from other large-scale conferencing systems (most notably the French Minitel system) must be applied to the new system design. The role of a moderator could be similar in some respects to that of program producer in traditional broadcasting, or an editor in publishing. How would the moderators be selected, and how active a role should they play? Aside from the use of moderators, what other safeguards can be used to maintain a high quality level in the conferences without unduly constraining freedom of expression?
- How would new conferences be created (voting procedures, etc.)?

4.2.8. Economic Issues

Although the users of the CEF will also constitute most of the service providers (and participating organizations will presumably not charge for their services), there are costs associated with the creation and maintenance of the infrastructure. Should this cost be borne by the users (and will this doom the acceptance of the system)? What other mechanisms (advertising, subsidies) can be identified to support the system?

Many online videotex ventures have failed or are struggling to survive - Bell Canada's ALEX system is an example. These systems are different in many respects to the proposed CEF system, but there are some common elements. These ventures need to be closely examined for lessons which can be applied to the design of the new system (this of course also applies to the engineering, human factors and other disciplines as well).

4.2.9. Social and Policy Issues

The creation of a national conferencing system would have wide-ranging social and political implications. It will be necessary to find partners with expertise in these fields who can address issues such as:

- Who will control the conferencing system and develop the policies for its use? Who is responsible for its content, and how will it be policed against abuse?
- Should the system be allowed to have commercial content? If so, what limits should be placed on this?
- Should the system support private e-mail in addition to public conferences? What are the implications in terms of the effect on other institutions (e.g., Canada Post), privacy, etc.?
- Should the use of the CEF for collecting information (polls, referenda, etc) be allowed?
- Since a home computer would be a requirement for accessing the CEF service, the service could be considered to be discriminating against low-income groups. Can access be made more universal by, for example, providing terminals in public places?

5. Issues Research

Issues Research deals with problems that apply to many new broadcast services and will need resolution before or during service design.

Four issues arose during our interviews which appear most urgent at this time, needing resolution before broadcasters would be comfortable with their role in providing these services. The issues are: video production, conditional access, interactivity and uplinks.

DGBT proposes to conduct the engineering and human factors issues, which predominate in these issues. DGBT has already investigated some of these issues in relation to previous projects, and has skills that can be readily applied to the others. There are some questions of economic and social policy as well, and for this research, partners would be sought.

Results of this research would apply to many new broadcast services, including the specific ones described in the Services Research section. The research would be undertaken with partners in the broadcasting industry in order to ensure that the research was realistically associated with their needs, but would not need the direct involvement of the partners in order to complete the research.

5.1. Video Production Technologies Research

5.1.1. Introduction

In the course of interviewing broadcast professionals in Canada, DGBT staff members were repeatedly told that technological solutions should be found which would make program production more efficient and less costly. In order to satisfy this need, while not duplicating the efforts of others, the problems must be approached in a new way. DGBT staff could add a new perspective to understanding program production by analyzing the tasks required to produce video using behaviour measurement techniques, producing models of these tasks, and then testing these models for their accuracy.

As well, knowledge of digital computers, multimedia technologies, and human factors can be used to look for opportunities to augment the production process. New ideas will be tested by working with the creators to change the function of the equipment until it works well for them.

5.1.2. Opportunities for New Broadcast Services

This is an appropriate time to begin research on production technologies because technology is changing rapidly. Digital technologies have become very inexpensive. We are beginning to see microcomputers become sufficiently powerful to manipulate video in real time. The proposed new television signal standards, new distribution technologies, such as video tapes, video disks, and direct broadcast satellites, and the development of new kinds of human interfaces, such as virtual realities and natural language interfaces, will all influence the direction of production for new broadcast services.

Several broadcasters are in a position to take advantage of new production technologies. CBC Television is designing and building a new production facility in Toronto, and TVOntario is experimenting with various multimedia production and distribution methods. Cable operators may welcome new ways to provide community programming.

5.1.3. Engineering Issues

Perhaps the most important engineering issue is interoperability between conventional broadcast equipment and new broadcasting equipment. Too often equipment manufacturers sell products which work well by themselves but do not fit easily into the studio with other equipment.

One of the problems noted by broadcasters was the need for easy access to data already created. Large files of video, audio, and other media from previous programming exist, but are not efficiently used.

5.1.4. Human Factors Issues

Equipment needs to be designed to meet producers' creative requirements, and at the same time be easy to learn and efficient to use.

Video production is already an interdependent system of equipment and people. Introducing changes into such a system must be done very carefully. Our previous work on office communications systems has provided a model of the introduction of new technologies. In particular, if new technologies are introduced faster than people can accommodate to them then they will simply be rejected.

5.1.5. Proposal for Research on Production Technologies

Research on production technologies requires five steps:

Model Production Processes: Observing how video is produced in a television studio is required to produce a quantitative description of the tasks, such as time spent on each task and what the task involves. Since different kinds of television programs require different kinds of video production techniques, more than one model will result. The model or set of models will show the resources required for each task and the interrelationships among the various tasks. These models will be a combination of structured systems analysis and behavioural models.

Develop Functional Specifications: Specifications for production technologies that will assist in the production process will be developed from the models. Production technologies must co-exist with the existing technologies, must be attractive to the video production professionals, and allow more efficient production.

Implement a Functional Prototype: A functional prototype will be implemented based on the functional specifications. The prototype must be as flexible as possible so that it can be modified as a result of empirical testing. Therefore, it will most likely be implemented in software on a general purpose computer using as little customized hardware as possible. When the technology is eventually manufactured, it may be produced as a much less expensive hardware device rather than as software.

Conduct Laboratory Tests: The functional prototype will be tested in a series of controlled laboratory experiments, first with casual users, then with television professionals. The purpose of the laboratory tests is to ensure that the prototype functions as the specifications intended, to find the best way to teach people to use it, to measure how efficient it is to use, and to discover people's general reaction to it.

Conduct Field Tests: The final stage is to test the functional prototype in field tests. The prototype will be used to produce actual television programs. This will ensure that the efficiency measurements and preferences obtained in the laboratory experiments carry over to the day-to-day production environment.

The outcome of a successful research project will be a prototype of one or more production technologies which can be used directly to make television program production more cost-effective, to allow individuals with less training to produce community television programs, and to provide functional specifications for a Canadian manufacturer to begin manufacturing and selling the new video production technologies.

5.2. Interactivity Research

5.2.1. Introduction

One of the central features of new entertainment and information services is interactivity. These applications are different from traditional broadcasting in that viewers interact with the material being presented or with the service provider. This type of interactivity is a challenge for broadcasters to provide.

Today, many viewers interact with broadcast material by using remote controls to change channels, and video cassette recorders (VCR) for recording and later viewing of program material. They can also be selective in their viewing by skipping over sections of programs or advertisements using the VCR technology. Although this interactivity is very simple, it has had a large impact on the timing of programs. For example, some broadcasters are presenting material at non-prime hours with the expressed desire that they be "time-shifted" by the viewers. This allows broadcasters to lengthen their broadcast days while still retaining an audience. An example of a broadcast system that provides still further interactivity is Videoway in Montreal. Videoway broadcasts four separate views of an event on four channels so that viewers may select the view they prefer. The main use for this facility has been for sporting events such as hockey games. Although such services consume a good deal of bandwidth, new developments in digital video compression will make them more feasible.

In the future, interactivity will increase. In the short term, viewers will be able to select and pay for specific programs that they want (pay-per-view systems). In the long term, viewers may be able to request specific programs (video on demand), or provide feedback to the broadcaster using some form of up-link (e.g., TV Answer). Along with interactivity comes the issue of program content. Viewers may wish to select information based on content rather than on program titles (e.g., "I want to record any news concerning the space shuttle."). In fact, at least one company is already offering an automatic television guide and VCR programming service that allows selection of programs by content. If viewers are no longer restricted to passively viewing what the broadcaster is sending at that instant, will there be a demand for different kinds of content?

We have also seen new systems where viewers are able to query the content in the programs (e.g., "What is the population in Kuwait now that the war is over?"). What is the best way for these questions to be formed, and how should they be answered?

Most of the issues presented below can best be addressed by developing or acquiring examples of multimedia systems in order to gather viewer's reactions.

5.2.2. Engineering Issues

- What demands on bandwidth will be made by interactive services?

- Can hybrid broadcast/local systems (e.g., accompanying broadcast material with embedded control signals for local CD-ROM players) reduce bandwidth requirements?

- How can an uplink from the viewer to the broadcaster be built into tomorrow's systems? What services could be developed today either without an uplink, or by using telephone or cellular radio uplink?

5.2.3. Human Factors Issues

- How should an interactive interface to new broadcast services be designed so that it is both powerful and easy to use?

- What are acceptable delays for various interactive services?

- Is there a preference for interactive or passive services? What types of programs are best suited for interactive services?

- What role does interpersonal communication play in interactive services? Do people want to interact with program content or each other?

- If there is a limited opportunity for interaction, are people willing to watch other people interact?

5.2.4. Policy and Economic Issues

- How can viewers' privacy be ensured?
- Will there be sufficient demand for interactive systems to make them economically viable?
- How will pay-per-view systems compete with traditional advertisement-based systems?

5.3. Conditional Access Broadcast Systems

Many new broadcast services would be economically viable if the user paid a portion of the cost. Methods of providing conditional access to services, in which users pay to receive services, are being proposed as part of the new broadcasting distribution infrastructure; for example, conditional access mechanisms could form an integral part of new high definition television and digital audio broadcasting systems.

There are some outstanding human behaviour questions that need answers before conditional access systems can be well designed to serve users. Two questions have been clearly defined so far: 1) how much bandwidth is required to provide these services; and 2) how should the access control system be designed to serve users best.

The amount of bandwidth required to provide conditional access services is one question that needs to be answered so that standards are set with adequate bandwidth. The amount of bandwidth required for a particular service will depend largely on the frequency with which the user interacts with the system. Bandwidth will also be influenced by the amount of information flowing to the user and its compression. The amount of user interaction will probably be determined by the type of service and whether the user is in an environment in which interaction is easy. For example, a user driving a vehicle may not be able to interact as freely as someone at home or in the office. An exploration of the type of services that might be offered to the various environments and the expected interaction would help to set the parameters for bandwidth requirements for these services.

A second important question is the design of the access system for users. It will be necessary to ensure that only users who have subscribed and are being billed for the service actually have access. This process should be as unobtrusive as possible so as not to interfere with the users' desire to use the service. One proposal for controlling access to broadcast services is to assign a "smart card" to authorized users which contains encryption information for a particular service. The card would be inserted into a slot on the receiver, and the system would verify authorization based on the information on the card. This may seem intrusive to the user. Another possible system might be speech interaction with the user. A speaker recognition algorithm could be employed to identify the legitimate user, while a speech recognition algorithm simultaneously decodes the vocalized service selection. Another method might use a fingerprint recognizer which scans a finger while it is pressed against a transparent keypad assembly used for interacting with the system. Again, exploration of the various options would enhance user acceptance of conditional access systems.

These human factors questions have been isolated from the design and implementation of conditional access systems because they are issues that are not being addressed elsewhere at this time. Conditional access broadcast systems are still in the very early stages of design at present, so that information about these questions could have substantial influence on system design.

5.4. Uplink Studies

All information services require interactivity at some level. At its most basic, the interactivity may be as simple as turning the pages of a book or flipping through TV channels. As indicated earlier, many interesting services are possible in which the user only interacts locally with an intelligent user agent which helps the user select the information he wants from that which is broadcast. For some types of services, however, the user must interact more directly with the service provider. The user then must have an uplink, and in some extreme cases, the uplink must have as much capacity as the downlink. There is also the large grey area in between, where tradeoffs exist between local and remote interactivity, and hybrid approaches are attractive.

In this activity, some representative candidate services would be identified, and implementation tradeoffs examined, such as:

- Given that a service were to be provided on a particular broadcast downlink, what are the uplink possibilities? How do they compare in terms of throughput, delays, cost, and convenience?
- How do such factors as local read-only or read-write storage and system response times affect the uplink parameters?
- How well do the possible uplinks scale as the number of users or the number of services increase? Can they handle the large peaks in demand generated by some services (e.g., viewer response systems)?
- What are the engineering problems associated with the use of cable systems for uplink? To what extent can they be overcome, and how does this affect potential services?.
- Is there a case to be made for allocating spectrum for uplink use, as is now the case (on an experimental basis) in the U.S.?

6. Conclusions

Recent initiatives in the broadcast industry indicate that the role of broadcasting is changing. In particular, interactive services are beginning to appear that use local storage of the broadcast information and only local interaction with it, or interaction via uplinks from viewers to the source. The latter configuration challenges the concept of broadcasting as only a unidirectional communication system. Some interactive services may employ cable as the uplink, while others may use cellular radio or telephone to permit interactivity. The interactive aspect and the hybrid infrastructures force a change in our perception that, for the good of the broadcast industry, should not be resisted. That is, broadcasters should be encouraged to compete using new ideas and technical possibilities, even when some services offered are not unidirectional and may include point-to-point communications.

A review of current developments in broadcast services suggests strongly that the future of broadcasting lies in the convergence of technologies related to broadcasting, computing, telecommunications, and publishing. Emerging technologies for both transmission and interactive multimedia applications may be integrated into new broadcast services which will appear very different from traditional broadcast services. Transmission infrastructures are starting to be complex hybrids and should be designed with applications in mind. As well, the design of applications should take into account the characteristics of the infrastructures that will carry them. It is in the integration of the application and infrastructure that many of the research issues occur. Questions arise in the engineering design, human interface design, economic, marketing, and social/policy areas that need to be studied for each service.

A fruitful partnership appears to be possible between the broadcast industry and the Department of Communications in the coming years. Broadcasters, with extensive production facilities for developing applications as well as networks for providing infrastructures, are in an excellent position to design new broadcast services and to provide them to the public. The Broadcast Technologies Research Branch (DGBT) is in a position to conduct research that will address the issues. The branch, in conducting this research program, can ensure that the Department's mandate in providing the basis for the orderly development of new broadcast services is met. At the same time, the branch can ensure that the needs of the broadcast industry and the goals of the Department of Communications are integrated, to ensure that the new broadcast services offered to the Canadian public are of the highest quality.

Toward implementing this partnership, a number of recommendations are made which would put the broadcast industry in a position to provide new broadcast services within the next few years and would put DGBT in a position to lead the research which would integrate both the Department's and the industry's needs.

- Broadcasters could take advantage of digital transmission and compression technologies to move large amounts of data to consumers' local storage for local interactive services. Research is needed on how to format the information and on the tools needed by users to make good use of it.

- Broadcasters could explore the feasibility of producing and selling CD-ROMS containing information that could be organized for presentation to the consumer by broadcasted control signals. Research is needed to design services that users will want.

- Broadcasters could investigate novel communications infrastructures, including hybrid channels and DAB systems, for offering new services. Uplink possibilities could be explored for allowing more interactive control of presentations by users, as well as for providing conditional access services.

- Broadcasters could work with the department to investigate the implementation of specific services to the public. Two such services are proposed in this report. Broadcasters could also work with the department in conducting research on some issues that apply to many services. The initial issues include improving video production, conditional access, interactivity, and investigation of uplink possibilities.

- DGBT could investigate novel broadcast systems of benefit to the public, including issues raised by the increased capability for user interaction. DGBT will continue to develop expertise in generic technologies and methodologies for application to present and future development of broadcast systems.

The proposed services to be investigated by the branch are those for which there is a perceived need. One is the "Advanced Traveller Information System" and the other is the "Canadian Electronic Forum". These are two examples of services which could be provided by broadcasters. Other ideas for services will arise as work with the service concept is conducted. As well, working with these service concepts along with partners will provide a basis for understanding the issues in more detail and for designing the methods for preparing new services more quickly.

The *Advanced Traveller Information System* (ATIS) is part of a major worldwide set of initiatives in developing Intelligent Vehicle-Highway Systems (IVHS). The project would be conducted in collaboration with other organizations including the transportation sector. A major issue to be investigated is the use of Digital Audio Broadcasting (DAB) as a means of distributing information to vehicles, and as a possible method for vehicle location. Broadcasters will be invited to provide the transmission infrastructure for the ATIS system, perhaps by including it as an ancillary service on new DAB system implementations. DGBT will contribute studies on various aspects related to the application of DAB and other communications systems to the IVHS system, as well as research to optimize a user's interactions with the information system given the constraints imposed by the mobile environment.

The proposed *Canadian Electronic Forum* (CEF) is intended to be a national computer-mediated conferencing system. The CEF would combine the information processing power of computers with the information dissemination capabilities of the broadcast networks. It would provide opportunities for Canadians to communicate with each other in a new way, seek information, find outlets for their creativity, and interface more easily with public sector organizations. Previous experiences with visual interactive systems in a number of countries have strongly indicated that people want to communicate with each other much more than retrieve information or conduct transactions electronically. A message from a CEF user would be sent via a narrow-band channel to a broadcast network, and broadcasted to all other users. Since all recipients ideally should receive the message at the same time to avoid confusions due to delays, a broadcast channel is a very attractive delivery system for CEF. Another compelling argument for using broadcasting is the ease with which it scales. The addition of a new user makes no new demands on the delivery infrastructure, and only a tiny increment to the capacity of the uplink system is needed.

The following proposed issues for research aim at solving problems faced by the broadcast industry so that it can improve productivity and provide new interactive services. The issues are common to many potential new services. These issues appear to be the priority ones at this time, although others will no doubt arise in the course of the research.

The cost of video production is a serious problem for broadcasters in Canada. Several broadcast professionals indicated that technological solutions should be found for various problems in production in order to reduce production costs. With their knowledge of behavioural measurement techniques, DGBT researchers can add a new perspective to understanding program production by building and testing models of the tasks involved. As well, they can use their knowledge of digital computers, multimedia technologies, and human factors to identify opportunities to augment the production process. The research would produce prototypes of production technologies which would make television program production more effective.

The relatively high level of interactivity proposed for new broadcast services raises a number of engineering and user issues that need to be addressed. The proposed research would investigate the nature of the uplink where it is required, as well as the user interface with the system. Most of the user issues arising from these scenarios can best be addressed by developing or acquiring examples of multimedia systems in order to gather viewer's reactions.

An aspect of interactivity which deserves separate mention is conditional access to services. The economic viability of certain types of broadcast services that do not have advertising revenues will depend partly on payments by the users. The methods developed to provide conditional access to services and accept payment will affect the bandwidth required for a given service. Experiments will investigate the human factors issues raised by requiring user authorization, including the effect on bandwidth requirements.

Many interactive services will require an uplink capability, from user to service provider. There are many possible ways of providing an uplink in the broadcast infrastructure. Their capabilities will be investigated and compared, both from engineering and economic standpoints.

Together, these proposals provide a web of interrelated research activities that should lead to significant and visible outcomes over the next several years. The Canadian public will benefit from the new broadcast services, the broadcasters will benefit from the new opportunities available to them, and the department will benefit from the increased visibility due to its support of creative new services.

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APPENDIX A
A Survey of Electronic Information Systems Worldwide

APPENDIX B
Current Trends Related to New Broadcast Services

APPENDIX C
List of Contacts

by

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APPENDIX A

A Survey of Electronic Information Systems Worldwide

A Survey of Electronic Information Systems Worldwide

A.1. Introduction

This appendix attempts to survey a wide range of electronic information services offered throughout the world. The survey is far from exhaustive, but it attempts to give a reasonable sampling of the range of these services, and to provide some details on some of the more interesting ones. The focus is on those services which are actually in existence (or have been in the past), or at least are in the planning stages and appear likely to achieve reality in the near future. The survey is restricted to those services which distribute information to the general public or organizations by means of electronic rather than physical media. Particular emphasis is placed upon those services in which a broadcast-type medium is used as the means for dissemination of the information; however, some services which do not currently use broadcast media are also described, such as online services available through telecommunications networks. It is important to be aware of these non-broadcast services, first because they may be competitive with broadcast services, and second because many of them have potential for being adapted to the broadcast environment. Conventional radio and television programming services are not included in the survey.

There are many ways to classify information services, such as by the type of information, type of user, method of user interaction, and so on. Each type of classification has its pro and cons. Here we have chosen to loosely classify services on the basis of their delivery mechanism to the end user. The two major categories in which services are considered are those using off-air transmissions (i.e., radiated signals) and those using wired transmissions (i.e., conducted signals) for delivery. The off-air category can be further subdivided according to whether the intended users are in fixed locations or are mobile/portable. This distinction may of course blur in some instances. Further subdivisions on the basis of the type of transmission service are possible. On the wired side, the obvious subdivision is services provided by cable operators versus those provided by telephone companies, although this distinction too will blur as time goes on and the level of integration of communications services in general increases.

Table 1 on the following two pages provides a concise summary of some of the salient features of a few examples services in the categories covered by the review: off-air services to fixed receivers, off-air services to mobile receivers, and services distributed by wired media. The table allows comparison of infrastructure features: distribution channel, return channel, and data rate; and application features: audience, program type, and format. It also includes cost to receive the service and status where they are known.

This sampling of services illustrates the variety of approaches to providing new services using broadcast technologies. More detail on each of the example services listed in the table is provided in the text.

TABLE 1

SOME EXAMPLES OF NEW BROADCAST SERVICES IN NORTH AMERICA

OFF-AIR SERVICES TO FIXED RECEIVERS

	INFRASTRUCTURE			APPLICATION				
EXAMPLE SERVICE	DISTRIBUTION CHANNEL	RETURN CHANNEL	DATA RATE	AUDIENCE	PROGRAM TYPE	FORMAT	COST TO RECEIVE	STATUS
2.1.1 **								
TV ANSWER	Hybrid - over the air satellite	over the air		public	entertainment	text graphics	US 12.95/mo	market trial
2.2.1								
PBS software distribution	VBI non cyclical	none	96kbs	schools banks	education information	? ?	? ?	service
2.3.1								
BCIS Boston Community Information Service	Hybrid - FM subcarrier and telephone	telephone for 75% of users none for others	4800 kbs downlink 1200-9600 uplink	public with computers	information	text	$5.00/mo receiver <$100	trial winding down

** number of the description of service in the text

TABLE 1 (continued)

OFF-AIR SERVICES TO MOBILE RECEIVERS

	INFRASTRUCTURE			APPLICATION				
EXAMPLE SERVICE	DISTRIBUTION CHANNEL	RETURN CHANNEL	DATA RATE	AUDIENCE	PROGRAM TYPE	FORMAT	COST TO RECEIVE	STATUS
3.2.1								
RADIO DATA SERVICE	FM Subcarrier	none	674 bps	public in vehicles	information about travel	text	$100 to upgrade car radio	pilot trial in US
3.3.2								
OMNITRACS	Satellite	yes satellite	5-15 kbs downlink 55-165 bps uplink	trucking industry	information	text	$5000CDN	service

SERVICES DISTRIBUTED BY WIRED MEDIA

4.1.2								
VIDEOWAY	Cable	telephone but most services in teletext mode	full cable channel 4-6 Mb/s	public	information entertainment	text & graphics with television	$18.95/mo includes pay TV but need cable too at extra cost	service
4.1.6								
DAN'S APARTMENT	Cable TV Analog - 6MHz channel	phone	full cable channel	public	entertainment	video	free	several in experiment

A.2. Off-Air Services to Fixed Receivers

Most services which make use of the radio frequency spectrum for delivery do so by piggybacking them onto existing radio and television services. This is not surprising, given the economies provided by piggybacking, the alternative delivery mechanisms (e.g., cable, Public Switched Telephone Network (PSTN)) available, and, of course, the lack of spectrum specifically allocated for new services.

A.2.1. Interactive Video Data Services (IVDS): An Introduction

This type of service may be delivered by off-air or wired distribution methods. Some implementations involve direct participation from the consumers such as in polls and contests, purchases of goods, requests of information, and home banking (paying bills, making transfer of funds or direct payment,...). Most of the applications are likely to be in the area of helping the consumer to choose and organize existing services. Examples include channel organizers to help viewers keep track of all channels offered via cable or direct broadcast satellite (DBS), making VCR programming easy via the use of electronic TV listings, and providing broadcasters with a way to offer specialized services such as Pay per View. It may also be possible in some implementations to offer access to electronic databases, although this is not included in the initial systems. There are at least three different companies which are developing systems to perform these functions over different media. Each is using a different hybrid scheme to provide the two-way interactivity required.

Despite being called interactive, these systems do not allow continuous feedback from the home. They let the consumer select from a number of predetermined options, and then they collect data from the in-home machines at regular intervals. None of them permits the level of interaction involved, for example, in searching an online database for information.

A.2.1.1. TV Answer (USA)

TV Answer Inc. is currently doing field trials of technology which will make a new means of interactivity available to broadcasters. TV Answer (Morales, 1991) is a viewer response system which is independent of the broadcast medium - it can be used for cable, satellite, or terrestrial TV broadcasting. The system is based upon a network of cellular radio sites, each of which covers a radius of up to about 10 miles. Each cell site can handle 10,000 customers, with whom it communicates by means of a data link in the 218-218.5 MHz band, just above TV channel 13. The Federal Communications Commission (FCC) has indicated that it intends to allocate this band to Interactive Video Data Services. Each customer has a receiver/transmitter unit which receives and stores information broadcast from the cell site, and also transmits uplink information in response to polling from the cell site. The operation of the system bears some resemblance to the QUBE interactive cable system described later in this report.

The company has estimated it would take 10,000 cell sites to cover the United States. The cell sites are linked by satellite to TV Answer headquarters, where downlink data is generated and uplinked data from customers is collated and acted upon. The information is also made available to broadcasters and other service providers by means of the same satellite links.

The TV Answer home unit is rented by the consumer for a flat monthly fee ($12.95). A handheld remote unit is also provided, and a plug-in card which provides VCR programming capability is available at extra cost. The information that is downloaded into the home units consists of TV program listings, interactive commercials, order forms for goods and services, order confirmations, news about TV Answer, and updates to the memory cards of the decoder.

A two year field trial which included 700 homes in the suburbs of Washington D.C. ended in March 1990. Of the 700 hundred homes, an average of 75-100 homes used the interactive service on a regular basis. The in-home units were connected to the cable converter box and answers were entered via the cable remote control device. New hardware has been developed for the second field trial; the new generation decoders have their own remote control which could also control most other electronics appliances (CD, TV, VCR, ...) as well as the TV Answer unit. The new design for a remote control is a pointing device allowing the selection of icons displayed on the screen.

The programming offered in the first field trail was a 30 minute interactive news program, 22.5 hours of continuous opinion poll, and one hour of music video programming, which was the most popular program. The company does not intend to get into programming or offering new services after the field trials. Instead they will make the technology available but let the marketplace decide on which specific applications should be offered locally.

TV Answer is an interesting innovation because it provides an uplink for interactive services which avoids some of the problems associated with other uplink possibilities. It may prove attractive to cable operators who are hesitant to invest a large amount of money to upgrade their systems for two-way cable operation. It is more efficient at providing fast updates and handling large peaks in viewer responses than a telephone-based system would be. Its potential applications for interactive services are somewhat limited, however. The aggregate data rate on the downlink from a cell transmitter to all subscribers is only about 9.6 kbs (this could be supplemented by data on the broadcast channel itself if the home unit included a suitable decoder). The uplink from an individual customer only provides a capacity of about 10 b/s, which is insufficient for some applications. In other words, TV Answer is best viewed as a store-and-forward system which can collect information on viewer preferences and allow them to select services (such as pay per view). It is not suitable for services which demand a higher degree of interactivity between the service provider and the user. It remains to be seen whether the applications for which TV Answer is well-suited will be sufficient to allow it to find a secure niche.

A.2.1.2. Interactive Network (USA)

Similar services to the ones offered by TV Answer have also been developed by a California company (Brown, 1991), with the notable difference that the information is loaded into the local decoder either via the FM subcarrier (9600 b/s) or in areas where the FM reception is poor via the VBI on a local TV transmitter. The return channel, as in TV Answer, is not always active; a phone connection is made at pre-determined intervals and data from the in-home unit is loaded into a central computer in short bursts of data of 10 or 20 seconds.

The in-home unit is a micro-computer with a built-in modem, a digital FM subcarrier receiver and a VBI decoder. A hardware encryption chip ensures security and prevents unauthorized access.

The type of interaction that is made possible is polling, playing along with sporting events or game shows, and delivering information services such as news, weather, sports, and stocks. The interaction is a store-and-forward system as in TV Answer. The in-home unit receives information constantly. Data is sent from the central computer to participating FM stations and Public Broadcasting System (PBS), which broadcast it to the home units in the subsidiary channel multiplexed operations (SCMO) or VBI, respectively.

A.2.1.3. Videopass (France Telecomm)

Videopass is a conditional access system for broadband networks, used in Europe on cable and satellite. It allows pay per view, flexible subscriptions, home shopping, management of subtitles and audio, and can limit access to some type of programs.

In-home units include a unique encryption scheme (EUROCRYPT developed by Centre Commun d'Etudes en Téléphonie et Télecommunicatrais (CCETT)) and works with personalized credit cards ("smart" cards), which can be used in any Videopass units in service. The units became available in 1990 and can be used with various transmission media: cable, off-air, satellite. The unique feature of this system is the personalized card which basically provides services to a specific person instead of a physical address. The security is increased by frequent change of the control word (every 10 seconds) and by the user key.

Eurocrypt has been selected by several satellite and cable operators in Europe, and more than 1.5 million decoders have been ordered.

It is not clear what return channels are used if any - it appears to be the telephone line. The cards are validated at special service points, which seems to be a weak aspect of the system but is required because some users do not have a return channel in their decoder. It is viewed as an advantage for allowing more control to the service providers and allowing a more flexible structure of cost recovery.

A.2.2 Services Using TV Broadcast Channels

There are several mechanisms available for transmitting ancillary data on television signals, but the use of the Vertical Blanking Interval (VBI) is by far the most common.

VBI data broadcasting is a one-way, point to multipoint data transmission technology. With VBI data broadcasting, it is easily possible to deliver information to a large number of people; for example, in Canada the signal from the CBC TV network alone can reach 99 percent of the population.

There are basically two ways that the VBI can be used to deliver data to the end user. The distinction between the two types of services has been made in Europe where there is already a significant base of end users. In North America where these types of services have not been very successful yet, these services have not differentiated between their mode of operation.

The first method, which is called teletext, requires a specialized decoder which displays the information on standard TV sets. Most high end TV sets, including all large-screen models, sold in

Europe are already equipped with a teletext decoder. The information is organized in pages to be viewed with very little formatting. The technology is already quite mature and was standardized when the costs of local storage and personal computers were quite high. Because not more than a few pages can be stored at the decoder, the database is continuously cycled which limits the amount of data which can be distributed without imposing undue delays on the users.

The second method, called datacasting, takes advantage of the possibility of local storage and uses a local computer to retrieve the information from local storage. Since the information is stored locally, it is possible to send a large quantity of data to thousands of receivers simultaneously. Access to a TV signal carrying data on the VBI, a specialized decoder attached to a microcomputer, and some software are what is required at the customer location. A specialized piece of hardware at the transmitter, a teletext inserter, is required to insert the data in the TV signal. Currently in Canada an inserter costs about $50K and a decoder is in the $400-$650 range. Costs would be likely to decrease significantly if it became a mass market item, as it is in some parts of the world.

Teletext is well established in Europe and in some parts of Asia. There are about 50 million teletext decoders now in existence throughout the world, of which more than 30 million are in Europe. In the United Kingdom (UK) alone, there are between four million and six million receivers in use and datacasting is starting to be popular, mostly in commercial services. In the U.S., VBI datacasting is beginning to find some applications, but in Canada it remains little used. A Canadian environmental newspaper "The Planet Today" is being transmitted by satellite and VBI, starting in April 1991. Field trials in Canada also have distributed local newspapers for the deaf, and up-to-date weather and road information (NGL Consulting, 1991).

The first 21 lines of each television field (National Television Systems Committee, or NTSC) make up the vertical blanking interval. Although some of these 21 lines are required by the television receiver for timing, and others are used for various test signals, 10 of these lines do not normally carry any information and can be use to transmit data. The 10 lines would allow a potential data rate of about 125 kb/s when used with the EIA teletext standard (North American Basic Teletext Specifications, or NABTS). Present decoders typically use four lines for a raw data rate of 50 kb/s (the effective data rate when overhead is removed is usually 9600 b/s per VBI line). To illustrate the potential, the text of a typical newspaper can be sent using four VBI lines in less than five minutes. The VBI of sequential colour with memory (SECAM) and phase alternation line (PAL) television signals are used for teletext in a similar way to that of the NTSC signal.

Although the VBI is probably the simplest means of transmitting ancillary data on a TV signal, other approaches are possible, albeit uncommon. One would be to add another subcarrier to the sound signal (in addition to the stereo difference and second audio program (SAP) signals), in much the same way that SCMO is added to FM signals. Another approach, which is particularly suited to sending still images, is to steal entire frames from the TV signal and insert new ones in their place. An example of the latter approach is the system developed by Cableshare of London, Ontario.

A.2.2.1. Public Broadcasting System (USA)

PBS has been quite active in developing applications for data delivered on the VBI (Garr and Richer, 1990). The data is inserted in the TV signal at the network control center and distributed to individual TV stations by satellite. The data is then separated from the carrying TV signal and inserted in the local station broadcast signal. Ten lines are used to transmit data for a total throughput of 96 kb/s.

The in-home VBI data receiver selects and decrypts the data, and relays it to either a computer or display device. Various applications are being tested.

Educational material is distributed to schools either as an adjunct to regular PBS programming material or as unrelated information: teachers guides, student worksheets, lesson plans, related databases, bibliographies, and so on. Interactive components will also be delivered in the future to allow the control and use of separate program segments. The software and technology are currently being developed. The first phase is under way with distribution of program support material and video indexing data. Custom software stores the information locally and provides access to the material stored.

Credit card authorization databases have been distributed via PBS's VBI since 1988. The "hot card" file is transmitted daily to the merchants and stored locally on the VBI data receiver, which has static random access memory (RAM) and is connected to the credit card authorization terminals. The system is user configurable allowing, for example, the merchant to get a credit approval number on the online system for purchase above a certain amount. The use of an electronic database speeds up credit approval compared to on-line systems, while allowing up-to-date information on stolen and unapproved cards.

PBS National Datacast is currently distributing real time financial data such as stocks, bonds and commodities around the country. PBS has in addition a few pilot programs. One with a major oil company is to download credit information, electronic messages and company specific data to its retail outlets. Another is with a pharmaceutical company, to deliver medical information and advertisements to physicians and pharmacists. A new application for the general public is the downloading of TV listings to make VCR programming easier. The hardware and software are under development. Other applications are also being considered, such as transmission of news and federal procurement information.

A.2.2.2. DATACAST and CEEFAX (UK)

In the UK, eight VBI lines are used to transmit information. The British Broadcasting Corporation (BBC) has developed a service called DATACAST which allows one way transmission of general data services for the public or commercial purposes using the existing teletext CEEFAX system as a carrier (Chambers, 1988). Both services can coexist without users of the other service being aware of it. DATACAST charges are based on the volume of transmitted data and a fixed charge for each receiver. Costs are of about $0.10 per kilobit of transmitted data and a license fee of $40 per receiver. The DATACAST receivers are typically supplied by an information provider and may contain a unique identity and decryption device, allowing the service provision to control individual receivers.

Euromoney is a hybrid information service on the European market. Each subscriber has a PC which can send messages to a host computer via phone lines and receive data via DATACAST. Subscribers can send messages to each other.

The Financial Times is running an electronic bulletin board on stock and bond exchange index.
The International Stock Exchange has a Market Eye service to broadcast real-time prices including security prices, traded options, gilt prices, and commentary to a wide range of subscribers in the UK.

Coral Racing has implemented a multimedia racing information and display services which include data, images, and control information from its London headquarters to 800 licensed betting offices.

A.2.2.3. CPLPS - Chinese Teletext System Based on NAPLPS

The huge Chinese character set complicated the introduction of teletext communications and has prevented the introduction of a teletext service based on one of the four International Radio Consultative Committee (CCIR) standards. China has opted for a NAPLPS based system but had to made significant modifications to the standard. The quality of TV signal reception is poor in a number of locations, which is indicative of a high bit error rate. Large scale applications of teletext in China are not expected until 1995 (Zhu and Gu, 1991).

Chinese Presentation Level Protocol Syntax (CPLPS) is a free format teletext protocol; the Chinese characters are generated by a bit-map scheme instead of a character generator in hardware, and decoders have compatibility with North American Presentation Level Protocol Syntax (NAPLPS) 7 bit environment. Resolution is 320 pixels X 252 lines which corresponds to 10 rows of 20 Chinese characters in text mode.

A.2.3. Services Using FM and AM Broadcast Channels

The basic means by which services are piggybacked on FM broadcasts is known as SCMO (Walker, 1989), for Subsidiary Channel Multiplexed Operations (the original term which arose in the U.S. was Subsidiary Communication Authorization, or SCA). This involves modulation of a new subcarrier centered at 67 kHz or 92 kHz, located above the subcarrier which carries the stereo difference signal. Similar techniques are used in Europe, but different standards are used. The SCA/SCMO standard was found to create unacceptable levels of crosstalk into the main program in many European receivers. The main reason for this is the tighter filter requirements in the European receiver which is necessitated by the use of 100 kHz adjacent channel spacing between stations (vs. 200 kHz in North America). The original intended use of SCMO was to carry a subsidiary audio program, and such uses appeared as early as the mid-60's, but many applications involving data transmission have appeared in the intervening years.

SCMO has been unregulated in the US in 1982. Since then, a wide variety of ancillary services have appeared, most of which are aimed at closed user groups rather than the general public. The majority of broadcasters have chosen to lease their subcarrier instead of operating the service themselves. A SCMO receiver costs about between $100 -$200.

The application which is most common is the delivery of specialized music services; about 60 % of the SCMO operations in the US are background music. A lease for a subcarrier to a third party could bring up to $5000 a month to a radio broadcaster, so this is a fairly lucrative business, considering the small cost to the broadcaster. Among the data services available, the most significant one is the delivery of data on the stock market. An average customer will pay a quotation service about $250 a month. One example of such a service is Lotus' Signal, which has been in operation since 1982. Other services in operation in the US include "talking books" for the blind, and educational material for specific audiences.

In 1986 the Department of Communications approved an increased baseband spectrum for FM transmission from 75 to 99 kHz and an accompanying increase of the total peak deviation of the main FM carrier. It then became possible to utilize the additional baseband spectrum for a wide variety of applications such as background music, data distribution, telemetry, paging and RDS (Radio Data System, described in the section on mobile applications). The applications are limited by the bandwidth, signal to noise ratio and crosstalk to and from the main program channel. This last criterion is somewhat dependent on the type of programming, as a station with an aggressive, loud format is able to endure more crosstalk than a station with a large proportion of classical music or other wide dynamic range material.

CBC studies (Sawyer et al, 1990) have identified 3 SCMO subchannels: SCMO1 which is used for RDS at about 2 kb/s, SCMO2 which carries an audio signal (10 kHz audio AM single sideband, or SSB), and SCMO3 which is used for data services such as stock markets and commodity exchanges (AM with vestigial side band suppressed carrier) at a data rate of 9.6 kb/s or 19.2 kb/s.

Due to the very limited bandwidth and type of modulation used, the possibilities for transmitting ancillary services on AM broadcasts are much more limited. The recent introduction of AM stereo demonstrated that there is some additional capacity available, but to our knowledge no ancillary data services for AM broadcast are in existence or planned.

A.2.3.1. BCIS: The Boston Community Information Service

The polychannel concept developed at Massachusetts Institute of Technology (MIT) marries the personal computer, broadcast technology and bidirectional technology to provide a new type of service to a large population. BCIS is a system designed to demonstrate the polychannel concept and to serve as a test bed for investigating user interface design and other issues (Gifford, 1990).

This system is designed to provide information services city-wide to ordinary citizens. In the case of BCIS, the polychannel system combines the use of a digital broadcast channel (FM) and a duplex communications line (phone). This unique combination allows the flexibility of a dedicated on-line service and the low cost of broadcasting delivery. The service is based on a personal computer which acts as an active medium to collect and display information according to instructions tailored to a particular user. The local computer maintains a local database by filtering the updates it receives from the FM broadcast, and when the local database is not able to process a request, the telephone line is use to connect to a remote server. It is expected that the majority of requests will be handled locally by the user computer. The actual source of the data is completely transparent to the user.

There are several advantages to a polychannel system over traditional dedicated data server. The cost per additional user is very low compared to a conventional server, and there is a higher level of privacy since the local computer is doing the filtering. There are also advantages in providing a return channel, in this case the telephone line, which allows electronic mail, transactional processing, and the potential to broadcast user generated data, which lower the cost of production.

About 200 homes and businesses participated in the field trial which started in 1985. The participants were computer literate and were required to provide their own personal computer for the field trial. The system was initially provided free with the obligation to fill out a two page questionnaire every month. The initial participants reported using the system an average of 31 minutes a day. Later on a user fee of $5 per month was charged and 68% of the users (89/131) began paying. Participants reported reading newspapers and watching the news less frequently while using BCIS.

Among the services provided were access to the electronic version of the New York Times and the Associated Press, some USENET newgroups, limited e-mail capabilities, and some software. The information is in a text based format and there are over 20 MBytes of data per day that is broadcast over radio channel (92 kHz FM SCA channel of a local FM station). The data rate is at 4.8 kb/s. The receiver has an RS-232 output and costs less than $100.

Each user has a personal computer that handles requests and maintain a local database. Interactions with the local database are done via a hybrid free-text and menu-based access. Requests which cannot be processed by the local computer are transmitted over a phone line to one of two servers at MIT. The content of the local database is tailored to individual users via a specified filter which determines which information is stored locally. Database content labels are used to route a query to the appropriate database. All broadcast data is encrypted to prevent unauthorized use, and a private key string is stored in the personal computer allowing the computer to select the information that the user is allowed to see.

Some of the problems reported by users were: having to dedicate their personal computer to data gathering for several hours a day, and the difficulty to produce appropriate filters and to eliminate duplicate information. Access to the servers at MIT was not used frequently. It should be noted that about 23% of the users didn't have modems, and only about 50% of those who had modems used them to access the servers.

The major result of that field trial was to demonstrate the usefulness of a personalized active information service at a fraction of the cost of on-line databases. The experiment showed that most user's requests could be satisfied via the broadcast data but that the access to the MIT server was essential to complete the type of services offered. One of the most successful features of the BCIS was the filtering of the information and the local storage which added value to the broadcast information.

A.2.3.2. Sofcast (USA)

Sofcast was a software downloading service available on radio stations in Seattle, Washington, and possibly other areas (Joyce, 1985). Data was sent over AM (2400 b/s) and FM (4800 b/s) instead of the audio program for short bursts of 10-20 seconds. Sofcast shows distributed data, programs, any type of electronic information at no cost to the end user. Like other radio and television programming, the costs were paid by sponsors such as computer stores. A weekly 30-minute show had a mix of interviews, demonstrations of special audio effects, review headlines in the computer industry, and answers to questions from listeners. The software was loaded into a special encoder from a PC which converted the data into an audio signal which could be broadcast or taped. The receiver (demodulator) was connected to a radio via the earphone jack and to a PC via a serial port, and a program was run on the computer to accept the stream of data and convert it back into a file. The receiver unit was known as the Shuttle Communicator, and cost about $70.

The Shuttle Encoder and Communicator were developed by a company called Microperipheral. The company has developed machine specific devices for the PC, Macintosh, Commodore, and a few others. The Communicator could also be used to access bulletin boards over the phone line, using a touch tone telephone to make the selection and downloading the data coming in over phone lines. The Sofcast service was offered several years ago (1984-85), and its current status is unknown. It seems likely that it did not survive in the wake of the proliferation of telephone bulletin-board systems and inexpensive modems that began in the mid-80's.

A.2.4. Satellite-based Services

A.2.4.1. Skypix - Direct Broadcasting Satellite Service

In 1993, a company called Skycable is expected to launch a 108 channel high power direct broadcast satellite. New DBS services using existing satellites may arrive sooner, however. Skypix has announced plans to launch a DBS service in late 1991 offering 80 channels in PPV movies, special events, and most popular cable services. The receiver cost is expected to be in the $1000 range, and it will require a dish less than one meter in diameter. The launch of this service has been postponed several times, and there are some doubts about whether it will get off the ground. There is no doubt that new DBS services are coming for North America, however. The FCC has issued a total of 9 permits for DBS ventures with a total of more than 262 channels. Some of these will no doubt fall by the wayside, but with advances in compression technology, even a small number of DBS services could provide many hundreds of channels. All of the services offered by USA DBS can be sold in Canada. Only Newfoundland does not have direct access to the satellites. In short, DBS offers the promise of high quality digital audio and video, many channels through the use of compression technology, cheap receivers (said to be potentially as low as $300 U.S., with dish antennas as small as 30 cm diameter), near video on demand with basic and premium services, and a variety of narrowcast specialty services.

A.3. Off-Air Services for Mobile Users

A.3.1. Mobile Services Using Dedicated Terrestrial Transmitters

A number of systems have been developed which, although they function in a broadcast mode, use dedicated transmitting facilities instead of piggybacking on existing broadcast signals. They typically use frequencies in or near standard broadcast allocations in order to avoid the need for special receiver equipment, although some have special assignments and require new receivers to be installed in the vehicle. Many of the new mobile information systems are intended to provide route guidance and traffic information, and fall into the general category of Intelligent Vehicle-Highway Systems (IVHS). A comprehensive survey of IVHS technology can be found in the report by Parviainen (Parviainen, 1990); a broader look at mobile communication systems, including telephone and paging systems, is available in the book by Walker (Walker, 1990).

A.3.1.1. HAR: Highway Advisory Radio (USA)

HAR (Turnage, 1980) is an American system which uses recorded voice announcements on dedicated low-power transmitters to provide traffic and road conditions, tourist information, and other related information. The frequencies of 530 kHz and 1610 kHz, adjacent to the AM broadcast band, have been allocated for this service. Coverage is generally limited to a mile or two, and drivers are generally advised of the presence of the HAR station by means of roadside signs.

One of the problems with this service is that although the vast majority of cars contain a radio capable of AM reception, a fairly high percentage them will not tune to these frequencies. In one survey, only 45% of car radios checked would tune to 1610 kHz, and 70% would tune to 530 kHz. Nevertheless, some 290 HAR stations were authorized in the United States by 1979. The present status of this service is unknown.

A similar service, known as HAIR (Highway Advisory Information Radio), has also been deployed in Japan. In this case, the frequency of 1620 kHz is used.

A.3.1.2. ARI: Autofahrer Rundfunk Information System (Germany)

Along the same lines as HAR, but somewhat more sophisticated, is the German ARI system developed by Blaupunkt. In this case, traffic information is transmitted by a network of some 40 stations in the FM band, which carry other programming when not carrying the traffic announcements. Tone modulation on a special subcarrier is used to identify the coverage area and to alert the user to upcoming announcement. A special decoder, which adds $15 to $30 to the price of a car radio, is needed to detect this subcarrier. About 80% of the car radios in Germany are said to have an ARI decoder, but most are of a basic variety which simply light a pilot lamp to announce the presence of an ARI station. More sophisticated units are available which allow the audio to be muted until a traffic announcement comes on, or to allow the driver to select the particular coverage zone for which he wants to be alerted to information. The most sophisticated and expensive units allow the driver to listen to the program of his choice, while a separate radio tuner section automatically tunes to the strongest ARI station serving that zone, and interrupts the program if a traffic advisory message occurs.

A.3.1.3. AMTICS and RACS: Mobile Information Systems in Japan

AMTICS (Advanced Mobile Traffic Information and Communication System) and RACS (Road/Automobile Communication System) are similar experimental systems which were designed to provide a wide range of information to drivers (Kawashima, 1991). Both systems provide a cathode ray tube (CRT) display terminal, a microcomputer, and a CD-ROM drive for mass storage. The static information available from the CD-ROM includes road maps, local traffic regulations, location of gas stations and tourist facilities, and so on. This is supplemented by dynamic information transmitted via the communications link to the vehicle, including traffic conditions, weather warnings, parking space availability, etc. Both systems also include on-board navigation systems which use dead-reckoning techniques supplemented with map-matching for periodic correction of accumulated errors.

The main difference between the AMTICS and RACS systems is in the implementation of the communication links. AMTICS (Tsuzawa and Okamoto, 1989) uses an approach modelled on the cellular telephone system, with a network of 800 MHz transmitters, each covering a radius of about 3 km. The signalling rate used on the link is 4.8 kb/s. Three transmitters were used for the tests in Tokyo which began in 1988. Although this is inherently a two-way system, signalling from the vehicles to the traffic information center does not appear to have been implemented. The map-matching update system uses a separate system of roadside microwave beacons operating at 13 GHz.

In the RACS system (Fukui et al, 1989), the navigation and communication systems are unified by using a network of short-range roadside microwave beacons operating at about 2.5 GHz. The data rate available is 512 kb/s, much higher than that of AMTICS. On the other hand, coverage is intermittent rather than continuous, since the beacon stations have a range of only 100 meters or so, and may be located several km apart. Two-way communications is a basic part of RACS, and a number of applications have been investigated. Among them are automatic vehicle monitoring (AVM), for monitoring the location and status of a fleet of vehicles, traffic flow data collection (e.g., by computing the travel time of vehicles between beacon locations), and automatic toll collection. Transmission of messages such as FAX, videotex, and voice mail are also under consideration. Some applications are limited by the highly intermittent nature of the communications, however.

Both systems have undergone a series of tests and demonstrations in the past five years. A new joint project known as VICS (Vehicle Information Communication System) has now been formed whose mission is to examine the results of these tests and to integrate the two systems into a unified system.

A.3.1.4. Autoguide and LISB (UK/Germany)

Autoguide (Catling and Belcher, 1989) and LISB (Sparmann, 1989) are the British and German versions, respectively, of a route guidance and traffic information system based upon the ALI-SCOUT technology developed by Siemens (von Tomkewitsch, 1991). This system provides the driver with a liquid crystal display (LCD) mounted prominently on the dashboard, and a handheld remote control un it. Unlike many other in-vehicle route guidance systems, the system does not have a map display capability. After the driver enters his destination (by map grid reference, prestored information, or possibly even postal code), the unit displays the "crow fly" distance and direction to it. As the trip proceeds, the on-board dead reckoning navigation system updates this display. In addition, the vehicle has an infra-red transceiver which is used to communicate with beacons along the route. The beacons are usually co-located with traffic signals. The vehicle-beacon communications link provides a relatively high data rate (up to 500 kb/s) and is two-way, so that the equipped vehicles can also be used as "probes" to gather traffic information and feed it back to the central computer. From the beacon, the on-board unit acquires location information with which to update its navigation system, and a set of vectors describing the routes available in the area. The display guides the driver along the selected route by showing the direction of impending turns and (in bar graph form) the distance to the turn, lane selection information, the correct exit to take from a complex junction, and so on. The display is supplemented with a synthesized voice unit which can provide audible directions such as "right turn ahead".

Some 700 vehicles have been equipped with Leit and Information System Berlin (LISB) in Berlin, and approximately 250 beacons have been installed. A similar size Autoguide pilot system is in the process of being installed in the London area (1000 vehicles and 350 beacons), and if it proves successful, commercial operation is forecast to begin in 1993. The installed price of the Autoguide vehicle units is forecast to be about £300, with an annual licence fee of less than £100 (Catling and McQueen, 1991).

A.3.1.5. Pathfinder (USA)

Pathfinder (Mammanon and Sumner, 1989) is a joint project of the U.S. Federal Highway Administration, the California Department of Transportation and General Motors. The stated objectives of the project are:

- To design, install and operate a system that will provide real-time traffic congestion information to motorists in their vehicles.

- To evaluate the driver's response to the information provided.

- To evaluate the utility of using vehicles as a source of information on traffic conditions.

- To evaluate a computer-assisted method of combining real-time traffic information from various sources.

The Pathfinder experiment is taking place in a 13-mile stretch of the Santa Monica Freeway between Santa Monica and downtown Los Angeles. The system encompasses the freeway, its service roads, and five major parallel arterials that may be used as alternate routes.

The vehicle system consists of three subsystems: the CRT display and associated processor, CD-ROM mass storage unit, and sensors; a single board microcomputer with voice synthesizer/digitizer; and the communications subsystem, which consists of a modem, ultra high frequency (UHF) radio, and antenna. The first of these subsystems is a commercial automobile navigation system called the Travelpilot (Buxton et al, 1991), which was jointly developed by Etak Inc. (Menlo Park, CA) and Robert Bosch. Its primary functions are dead-reckoning navigation and display of maps and other information. The microcomputer acquires location information from the Travelpilot system and transmits it to the central system, using a time-slotted channel access procedure to avoid collisions with transmissions from other vehicles. The communications take place at 420 MHz, at a rate of 4.8 kb/s. The central computer combines this information with data collected from other traffic-control computers. Other information, such as traffic accidents or other incidents reported by police, can be entered into the Pathfinder central computer by an operator. The central system broadcasts the congestion data to all of the vehicles once per minute.
The congestion information is displayed both as text, and as symbols overlaid onto the map display (which can be zoomed in and out). Audible versions of the data are also provided by means of a mixture of digitized and synthesized voice, coupled into the car audio system.

The Pathfinder system evaluation was scheduled to begin in April 1990, and to continue for about two years. Expansion of the system to cover the Los Angeles region could take place in 1993-94.

A.3.1.6. TravTek (USA)

TravTek (Jurgen, 1991; Rillings and Betsold, 1991) is another joint program of General Motors (GM) and the U.S. Federal Highway Administration, together with American Automobile Association, the Florida Department of Transportation, and the city of Orlando. The vehicle equipment will be similar to that used in the Pathfinder experiment; it may be based upon the same hardware, but this is not clear from the available descriptions. The equipment will be installed in 75 rental cars and 25 private vehicles. The video monitor in the vehicle can be used to display several types of information, including:

- Maps of the Orlando area graphically representing the location of traffic incidents and congestion.
- Directory information about hotels, restaurants, and services.
- Route guidance instructions using simple intersection schematics and directional arrows.

Descriptions of the operation of TravTek closely resemble those of Pathfinder, and it seems likely that same type of UHF data link is used between the participating vehicles and the operations center. A one-year trial of the TravTek service is scheduled to begin in Orlando in January 1992.

A.3.2. Mobile Systems Using Existing Transmission Facilities

A.3.2.1. RDS: The Radio Data System

RDS (Walker, 1990) is perhaps the first mobile information system that makes use of digital transmission techniques. Development of RDS began in the 1970's, leading to an agreement on its specification by members of the European Broadcasting Union (EBU) in 1983. Car radios containing RDS decoders first became available in 1987.

RDS makes use of a 57 kHz subcarrier in an FM broadcast signal (above the stereo difference signal, which is centered on 38 kHz) to transmit a data stream at 1187.5 b/s. When addressing and error protection overhead is removed, the actual data rate available for applications is about 674 b/s. RDS can coexist with the ARI system described previously.

The basic application for which RDS was developed is as an aid to receiver tuning. The system can provide, for example, identification of the particular program service being broadcast and its type (e.g., drama, classical music), and a list of alternate frequencies on which that program can be received in adjacent service areas. An RDS-equipped receiver can automatically scan these alternate frequencies and switch to them when their reception quality exceeds that of the transmitter currently tuned in. This is obviously more useful in the European context of public broadcasters with nation-wide coverage via many transmitters than in North America where private broadcasters predominate, but the ability to scan for certain types of program would certainly be useful anywhere. The system can also be used to send an alerting signal on all transmitters in a given area, causing receivers tuned to those channels to temporarily retune to another transmitter, on which is being broadcast an emergency announcement. Most of the information, however, is sent in coded digital form and then turned into a voice announcement by a voice synthesizer at the receiver. This allows users to receive the announcements in the language of their choice.

Other information which is typically transmitted on the RDS channel includes date and time, and text for display or output by the voice synthesizer. RDS has also been used for implementation of paging services. A more recent development is the specification of a traffic message channel (TMC) for RDS (Davies, 1989) which would use it as a transport mechanism for traffic information to the vehicle, probably linked to an on-board route guidance system of some sort. The main drawback of the TMC is that it has very limited capacity - about 200 b/s at the most. Consequently, a good deal of work has gone into the development of dense coding schemes for the traffic data which make the most of this low data rate.

RDS seems to be well on the way to becoming available in most parts of Europe. All major EBU members have stated their intention to provide RDS services, with the UK, Sweden, France, and Germany in the forefront. All BBC FM transmitters currently have RDS; however, the initial service provides only static data (e.g., program service name, alternate frequency lists) since the infrastructure to provide dynamic information takes longer to put in place. The number of RDS-equipped car radios is probably quite small at this time, but the rapid deployment of basic RDS services should help to avoid the "chicken and egg" problem. So far, RDS has made very little impact outside Europe, but a number of administrations are reportedly studying it closely. Some demonstration projects are underway in the U.S., and GM has reportedly announced plans to make RDS-equipped receivers available as an option in some cars, beginning with the 1993 model year. The premium required for RDS capability in a receiver will probably be about $100.

A.3.2.2. Trafficmaster (UK)

Trafficmaster, developed and marketed by a company called General Logistics, is said to be "the first commercially available, in-car traffic information system, capable of automatically alerting drivers with up-to-the-minute information on motorway congestion, to become operational in the U.K." (Catling and McQueen, 1991). The system uses infrared sensors mounted on highway bridges at roughly 3 km intervals to monitor the flow of traffic. If the traffic flow falls below a preset threshold of 40 km/h, the sensors send a signal over a radio link to the control center. The control center in turn sends the information to the vehicles via a VHF radio paging system. The congestion information is shown on in the form of a map display on an LCD screen, which automatically zooms to show a close-up of the problem area, accompanied by an audible alert. The screen shows the location, speed, and direction of the holdup along with an indication of its size. It can also provide supplementary textual information on the nature of a particular congestion problem; the system does not, however, provide recommendations on alternative routes.

The vehicle unit is portable, so that it can be used to obtain travel information before the user sets out on the journey. It also provides general-purpose paging functions. The Trafficmaster unit must be purchased by the subscriber, the current cost being £295; in addition, there is a monthly charge for the service of £18.5. The system went into service in September 1990, and the plan is to cover all of the motorways within a 55 km radius of London.

A.3.3. Satellite Mobile Services

Satellite communications obviously has considerable importance for services requiring wide-area coverage, particularly for remote areas where terrestrial facilities are very limited or nonexistent. This area is still in its infancy, and most systems are still on the drawing boards (two which are operational are described below). Possible applications, as enumerated for the Canadian MSAT system (Pedersen, 1990), include two-way voice communications to land, aeronautical, and maritime platforms; fleet management of truck and bus systems; transmission of weather maps, marine charts, and ice information to vessels; monitoring of oceanographic data collection buoys. The applications involve both point-to-point and point-to-multipoint communications. Examples of the latter include the map transmissions and some aspects of fleet management.

A.3.3.1. INMARSAT

The INMARSAT maritime communication system (Walker, 1990) went into service in 1982. It covers most of the earth's surface except the polar regions by means of three geosynchronous satellites. The basic service provided is known as *standard-A*, which uses analog FM transmission to support telephone and telex services. A terminal providing one telephone and one telex channel costs in the neighbourhood of $40,000 and uses a 1.2 m diameter dish; consequently, they are generally found only on the larger ships. Approximately 7000 terminals have been installed.

More recently, a lower-cost data-only service known as *standard-C* has been introduced. This provides store-and-forward data communications at 600 b/s. The terminals for this service operate in half-duplex mode and can use omnidirectional antennas. The cost is roughly an order of magnitude less than for the *standard-A* terminals. It also offers some new capabilities, such as the ability of the satellite to broadcast messages to groups of user terminals. This service appears to be aimed at the operators of small ships, and at land-based applications such as truck fleet management.

INMARSAT has also proposed a new system known as *standard-B*, which would provide digital voice services at 16 kb/s. This new service would apparently be coupled with the introduction of ISDN services at some future date.

A.3.3.2. OmniTRACS (USA)

Unlike the INMARSAT system, which was developed to serve maritime users and is now seeking markets in other areas such as land mobile, the OmniTRACS system (Jacobs and Bernard, 1991) is specifically targeted at land mobile users. Developed by QUALCOMM Inc. (San Diego, CA), this system is being marketed primarily to the long-haul trucking industry as a fleet management tool to replace a chaotic and inefficient driver phone-in system. Applications in other areas such as public safety, transportation, public utilities, and agriculture have also been cited. As of April 1990, about 8000 mobile terminals were in operation in the U.S., and a European demonstration system was operational. The initial system covers all of the continental U.S. The main reason for its relatively rapid deployment compared to MSAT, for example, is that it uses facilities (Ku-band transponders) on existing geostationary satellites.

The system uplink from the mobile terminal to the satellite has a low data rate (55 to 165 b/s) and uses spread-spectrum modulation to avoid interference to and from other satellite users in the same band. The downlink to the mobiles is higher speed (5 - 15 kb/s), but is shared between all the mobiles, which can be addressed individually or in groups. The mobile terminals use a mechanically steerable low-profile antenna which automatically tracks (in azimuth only) the satellite. Also included is a LORAN-C receiver for vehicle location determination. The display unit has a 40-character by 4-line display and a keyboard, including function keys for preprogrammed functions. The cost of a mobile terminal is about $4500 US.

A.4. Services Distributed by Wired Media

A.4.1. Cable Television Systems

A.4.1.1. Cable TV in Canada

Canada is one of the most cabled nations in the world, second only to Belgium (Careless, 1991). Cable passes nearly 90% of the households with TV in Canada, and about 74% of TV households are connected (by province, it ranges from 49% in Prince Edward Island (PEI) to 84% in British Columbia (BC)). In Canada cable television broadcasters are a very important part of the Canadian broadcasting system, being the distributor and packager of programming and information services to the public.

The total number of basic service subscribers in 1989 was 6.89 million (78.4% of households passed) and expected to be 8.74 million (83.3% of homes passed) in 1996. However, premium channels have not been as successful in getting Canadians consumers interested, and the number of homes that subscribe to speciality channels has been steadily declining since the fall of 1988 from 13.6% of the cable subscribers to 11.2% of the subscribers in 1990.

The major motivating factor in achieving such a high penetration was the desire of consumers to see the U.S. channels. There are more than 1600 separate cable systems in the country. The leading companies, both in terms of numbers of subscribers and technical innovations, are Rogers Cablesystems and Vidéotron Ltée. Rogers has a fibre optic backbone system in place, and is working towards the goal of "fibre to the neighbourhood" (Hart, 1991). In terms of innovation in services, the clear leader is Vidéotron, with the Videoway system described below. Aside from Vidéotron's exploration into the realm of interactive video, cable operators in Canada are largely preoccupied with overcoming the regulatory and technical hurdles preventing them from offering a larger selection of movie channels. Their major concern at the moment is with winning back market share from the video rental industry. Canadians spend $1 billion annually on movie rentals while the cable premium service takes in only $220 million a year. The cable industry is fighting movie rentals by introduction of pay-per-view into eastern Canada in 1991. They expect to sell movies at about $4.00 each to compete with the rental price of about $3.50.

Another threat facing the cable companies is the forthcoming direct-broadcast satellite services such as SkyPix. Although the threat is a serious one, the technology being developed for these services also represents an opportunity for the cable companies. If cable companies are allowed to compete in offering comparable services, they can take advantage of the same compression schemes and receiver addressability technology. The fact that cable is already in most of Canadian homes, plus the cost and siting problems associated with DBS receivers, puts cable companies in a good position to offer new services to Canadians. With compression of as much as 8:1 and universal receiver addressability, cable distributors will offer close to video on demand to their subscribers.

Coaxial cable trunk lines in many systems are being replaced by fibre optic cable to the bridge. At the bridge optical signals are converted to electrical signals and sent down the coax. At this point there will be at most three amplifiers in the coaxial cable link to the home. This situation can provide 1 GHz of bandwidth to the home or 150 6 MHz channels. In the meantime, some systems are being upgraded from 300 MHz to 550 MHz bandwidth, or from approximately 37 to 75 channels respectively. High density television (HDTV) is expected to be an all digital signal in a 6 MHz bandwidth which can be digitally processed. One possible scenario for a 1 GHz cable system (Ciciora, 1991) would have 60 NTSC channels, 30 HDTV channels, and 60 additional 6 MHz slots to carry digital compressed video. With good-quality 5:1 compression considered to be quite realizable, this system would then have a total of 390 channels of video available.

The goal is to have universal addressability so that channels, billing, and services can be allocated to subscribers remotely from headend. The success of premium services will hinge on packaging and diversity; completely addressable home receivers will make specialized services viable. We will see a diversity of narrowcasting services to subsets of interested subscribers.

Interactive services can use the 5-30 MHz return channel on the cable, or the telephone network. At present the return channel technical aspects have been fully tested, but two-services imply higher maintenance costs and the economics are generally considered to be unfavourable for the introduction of such services at the moment. These limitations may leave some room for separate systems providing dedicated return channels to succeed, such as the TV Answer System.

Rate regulation and the increasing costs of the annual royalties paid to the Copyright Board have curtailed the cable industry's profitability and have increased the level of uncertainty in its financial future. This has decreased investor confidence and declining share prices have caused cable companies to curtail capital expenditure on various programs. Up to now regulations have prevented the telecommunications companies from holding broadcasting licences and the cable companies from operating telecommunications network. The current climate of deregulation and the convergence of the technologies will likely change the situation. The cable companies are looking at the telecommunications market as a promising but unproven business opportunity. There is a potential to offer personal communications services and develop a personal communications network (PCN) to compete with the telecommunications companies.

Tight money, the competition of movie rentals and the imminent introduction of low cost direct broadcast satellite movie services make new information services on cable a low priority for the next 5-10 years. The problems faced by Canadian cable companies are not primarily of a technological nature, but regulatory and financial.

A.4.1.2. Videoway Interactive Cable TV

Vidéotron Ltée in Montreal and Quebec City have combined videotex with cable television to produce a large number of services under the name Videoway (Dufresne, 1991; Phillips, 1990). Current services are one-way, but two-way interactive services are planned for the future. They currently provide one-way interactive services by transmitting four television channels and a fifth data channel. The service provides a special converter which interfaces to the user via on-screen menus integrating user programmable favourite services and parental control. The special decoder/converter makes updates of pay TV services very easy as well as pay-per-view services without creating bottlenecks. It also gives the viewer limited control on the content, giving the viewer the choice, for example, between different camera angles, or in a game show or education programming presents different material depending on the viewer's answers. Viewers are presented with different program choices while watching the same show. For example, while watching a hockey game the user can instantaneously choose any of the four camera angles. Videoway has produced interactive sports shows, quiz shows, talk shows, children's shows and rock concerts.

The next generation system will provide two-way transactional services. Users will be able to select programs by content rather than by time and channel, and the system will be designed to be easily usable by the elderly and handicapped. Videotex graphics can be overlaid on television programs. Pay-TV or pay-per-view programs will be ordered by the user by a telephone call or via the two-way cable communication module.

Multilingual subtitling, captioning, teletext, Email, software downloading, video games, data downloading, and database access are services provided by Videoway. They are accessed the same way as pay-TV. Additional services include home security, energy management, medical alert, video catalogues, teleshopping, telebanking, TV audience metering, and others. There is the possibility of the company using Conversational Hypertext Access Technology (CHAT) (developed at CRC) in their Videotex system. The telephone, keypads, and/or joysticks are used to access or control the use of a service. Approximately 80,000 subscribers have signed up for the premium service, which represents about 10% of their existing subscriber base. This may give a misleading picture of the popularity of the new services, however, since the premium movie channels are not available separately from the Videoway service. The company is expanding into the European market via its subsidiary in London (UK), and is also preparing to move into Alberta. They have made plans to market their system via satellite to other cable systems around North America, but cable operators in general seem to be taking a "wait and see" approach to this system. Development costs of the Videoway system are said to be about $50 million.

A.4.1.3. QUBE

Although it is no longer in operation, the QUBE system (Weinstein, 1986) of Warner Amex Cable Communications Co. (USA) is of considerable historical interest, because it was commercial offering of an interactive cable service. Unlike the hybrid systems which have appeared later, QUBE made use of the cable medium for both uplink and downlink.

The QUBE system first appeared in Columbus, Ohio, in 1977. It was eventually extended to five other cities, and at its peak it had about 300,000 subscribers. It was not a financial success, however, and the company began withdrawing the service in 1984.

Technically, the system used frequency shift keying (FSK) data transmission at 256 kb/s on the cable, with the downlink at 124 MHz and the uplink at 25 MHz. The subscriber units were polled by transmissions from the hub to which they were connected (each hub served 10,000-15,000 subscribers), and the polling of all the units could be completed in about 15 seconds. The subscribers had a remote unit on which to register their responses to menu choices shown on a QUBE video channel. The system was primarily used for ordering pay-per-view services and for conducting polls related to the program content. For example, viewers could be asked to score each round of a boxing match, and the results would be tallied and shown overlaid on the screen while the match was in progress. Services such as home banking and shopping were contemplated, but they did not materialize, largely because of limitations in the response time and overall capacity of the system.

A.4.1.4. Time Warner's "Cable System of the Future"

On March 7, 1991 Time Warner announced that it would implement the first phase of the two-way interactive "cable system of the future" in the borough of Queens New York (Feder, 1991; Ciciora, 1991). A final system will use fibre to the home. Initially, the system will use "fibre-to-the-feeder" bringing three fibre trunks to neighbourhood nodes. These nodes will amplify and combine the received signal into a single one gigahertz (1000 MHz) signal for transmission over the coaxial local network. Currently coax supports 75 TV channels in a 500 MHz bandwidth. The 5-30 MHz band on coax will be used for return signalling. The capacity of the fibre backbone before compression will be 150 channels.

The initial system will have limited interactivity. A future system will be able to handle applications such as voice interactivity, linkages with computers, fax machines and personal communication networks, electronic banking, travel booking and remote medical diagnoses.

A total of 50 channels, 40 of which will be movies, are expected to be used for "impulse pay-per-view". The company is exploring the potential of providing local news, financial information programming, neighbourhood "narrowcasting" programs, as well as current multiple languages. The user will require an advanced addressable 150 channel converter with a character-generating chip to use the system.

A.4.1.5. On-Demand Interactive Video (UK)

British Telecom has been working a switched-star cable-television network with a large expandable bandwidth and interactive control allowing video on demand. The customer can access a video library facility containing a large catalogue of entertainment and instructional programs through their keyboards. Any copy of a program accessed by the user is made available solely to that user for the duration of the session. No other user can watch that session even passively.

It is estimated that the library can handle 250 simultaneous sessions serving 10,000 to 20,000 customers connected to the switched star network. A field trial is presently done in the city of Westminster. The customer uses a hand-held infrared keypad to interact with the system.

The Laservision disc (optical read reflective disc) based on the Sony/Philips standards was chosen over others. Three of these discs can be mounted in a 2x2x2 metre cube with maintenance required from one side allowing side to side and back to back installation.

While viewing a video, a customer has control over a video similar to a VCR such as PLAY, STOP, <STEP>, <SLOW>, <<SEARCH>>, FINISH, LIBRARY (to enter service), FACILITIES (to go to a menu of options), PAUSE.

A small 16 bit micro PDP11/23 computer controls and administers the whole library and user sessions. Costs to access a video tape will be comparable to obtaining it from a video rental store.

A.4.1.6. Dan's Apartment

"Dan's Apartment" is not really a service; rather it is an experiment in interactive television which may serve as a prototype for future services. Dan O'Sullivan is a graduate student in the New York University's Interactive Telecommunications Program, and his apartment is the subject of a late-night program shown on a Manhattan Cable channel. The program consists simply of video images that were recorded in his apartment and stored on videodisk. The interesting aspect of the program is that viewers can control the tour of his apartment by using their telephones to interact with the Amiga computer which controls the videodisk player. The computer has a simple speech recognition unit which enables it to recognize a small number of commands such as "go", "turn left", and "reverse". The available commands are shown superimposed on the video screen, with the one currently in force shown highlighted. A single caller can thus take a self-conducted tour around the apartment, while the other viewers watch. After a certain number of moves, callers are thanked by recorded voice for their participation, and the line is dropped to allow another caller to take over the tour.

Despite the mundane subject matter and relatively primitive technology involved, "Dan's Apartment" has proven to be a remarkably popular program. Many people have spent hours attempting to get through and become the next "visitor" to the apartment. Perhaps because of the unpredictable nature of the program, there seems to be a fascination which draws people to watch it even when they are not the ones interacting with it. This is an example of an interactive broadcasting technique which may provide some hints of things to come in the future of television.

A.5. Services Distributed by the Public Switched Telephone Network

A.5.1. Videotex Services

Videotex services are accessed via the telephone network. Telecommunications companies usually do not offer specific videotex services themselves; the services are offered by third-party service providers. The telecommunications company typically provides a central facility to handle the communications aspects and the billing.

Specific videotex decoders can be rented from the telecommunications companies or software emulating a decoder running on a PC with a modem can serve as a terminal. Users are usually billed per minute for usage of the services.

Videotex services exist worldwide; the French system and the Canadian system are described here as examples. The information accessible on videotex services is mostly text; some graphical capabilities are currently available and it is expected that photographic images will become available.

A.5.1.1. Teletel (Minitel - France)

France's Teletel System nears eight years of service and has 5 million users enjoying 12,000 services. Teletel generates 1 billion $US in revenues a year and handles 1.2 billion calls per year.

France has taken an active role in ensuring success for its Minitel service. The PTT (France Telecom) has invested billions of dollars in the system; it makes free terminals available to the public and delivers the telephone directory electronically. After 10 years of subsidies the Teletel service is only now starting to break even (if it has indeed turned the corner and is now generating a profit, it is the only videotex system in the world about which this can be said). Because of the large consumer base in France, a wide range of videotex services have quickly been offered to the public and Minitel has now a much higher penetration rate in the general public than videotex services elsewhere. The Minitel decoder provided by the post telephone and telegraph (PTT) is a dumb terminal limited to a few lines of characters but it is very easy to use.

Most of the services are not offered by the PTT but by numerous companies, which has created some problems in getting the public aware of the various services offered and limits somewhat the types of services used by a specific user. Half of the services are provided by large corporations and 45% of users are professionals. Studies have shown that the general population use only a few of the services offered on Minitel and that a minority of users generated the bulk of the transactions that are made on Minitel. The most common application used on Teletel is not surprisingly consulting the telephone directory (16% of the users used only that function of Minitel in 1990), and chat services account for roughly 15% of Teletel traffic.

French consumers have access to banking and travel information, market information and forecasts, home shopping and making reservations. There are 70,000 hearing impaired users who have access to full text and graphics, real-time electronic messaging, bulletin services and electronic conferencing with up to three users simultaneously. For the hearing impaired this is an upgrade to services and functions previously unavailable to them.

Teletel has moved to the USA with its 12,000 services at 160 locations. US companies can also market their online services to 5 million French subscribers. Linkages between the French system and videotex systems in Italy and Germany have recently been created. Teletel is now pursuing similar ventures with Japan, the UK, Belgium and Hungary.

A.5.1.2. The ALEX Videotex Service (Montreal and Toronto)

Bell Canada introduced the ALEX network in Canada in 1988 (Zurakawski, 1990). ALEX went into full commercial service in Toronto and Montreal in April 1990. The user requires an ALEX terminal (rented from Bell Canada for $7.95/month) with an internal 1200 baud modem, a tone decoding circuit for call waiting, a telephone connection, and a monochrome screen. A personal computer can also be used with the system; it needs emulation software and 1200 or 2400 baud modems. A software package for a PC that emulates ALEX terminals sell for $50.

ALEX is an on-line electronic service for the delivery of text and graphic information to the general public. The service provides a common user access interface through the basic telephone network. There are no terminal profiles or setup procedures required; a seven digit number gets you into the ALEX directory at no charge. Entering a simple name will give automatic access to a service provider's application. Currently there are over 450 service applications offered by more than 125 service providers.

ALEX offers information and transactional services primarily for the residential market. These include home shopping, home banking, entertainment, ticket reservations, restaurant reservations, and more. The three participants in ALEX are: the consumer, the network provider or carrier, and the service provider. The users are connected to the PSTN which accesses a Videotex Access Point (VAP) which routes their requests to the appropriate service provider via a packet switched data network (Datapac). The VAP does the billing for the user and service provider.

Servers at the service provider support information retrieval, data entry (form filling), store and forward messaging (electronic mail), two-way real time messaging (chat line), and processing intensive applications such as games and others.

ALEX specifications have been developed based on ISO (International Standards Organizations) seven layer open system interconnection (OSI) model. The computer and higher speed modems and eventually the ISDN network will become a part of ALEX. Future applications will bring still frame photographic quality images and multi-media applications with text and voice overlay. When the local-loop access bandwidth can support multi-media applications, many services may be offered which can use simultaneous voice, text and a full video image.

Recent indications are that the ALEX service is in trouble, at least in Toronto ("Bell shopping...", 1991). The number of subscribers there, which peaked at about 31,000 in December 1990, has levelled off since then and is now beginning to decline. Not only has the growth of the subscriber base stalled, but the existing subscribers are using the service less than they used to.

A.5.1.3. Videotex in Japan

As in North America, videotex services have been very slow to catch on in Japan. The Japanese system (from Nippon Telegraph and Telephone Corporation, or NTT) is known as Captain. There are currently only about 110,000 Captain terminals in use in Japan. However, a new joint venture involving 30 Japanese firms has recently been set up to revive the sagging videotex industry. They plan to give away 50,000 terminals by March 1992, with one million to be distributed within five years ("New Japanese...", 1990).

A.5.2. Online Services

Online services send information from computers over phone lines, satellites, or other broadcast media to subscriber's terminals, teleprinters, or personal computers. The final link to the user is nearly always by means of a modem and telephone line.

Online services may be categorized into the following areas: general interest, financial, scientific, technical, professional, credit reporting, marketing information, news, airline, and travel services. Other services include electronic mail and transactional services (electronic banking, entertainment).

A typical example of a system providing many of these services is CompuServe Information Systems. It offers electronic mail, conferencing (both real-time and through message forums), access to databases such as the official airline guide (OAG), home shopping, news, interactive games, and software downloading. Many companies, primarily software vendors, also use the service as a means of providing product support to users. One of the largest and most successful online services, CompuServe has about 800,000 subscribers, who pay a $1.50 monthly fee plus $12.50 an hour for connect time (certain services, such as home shopping and uploading of software by users, are free of connect-time charges). Navigating such a huge online system can be a daunting task for users, but a number of programs have been written which allow users to automate the process and minimize the connect time.

Another online system with a similar number of subscribers and a wide array of services is Prodigy. A joint venture of International Business Machines (IBM) and Sears, the Prodigy system has grown very rapidly and appears to be one of the few major success stories in the videotex industry (Sieck, 1991). Prodigy was launched in 1988 with a $30 million advertising campaign. Its rapid growth seems to be largely due to a flat-rate pricing structure, and the wide availability of introductory membership kits in locations such as computer stores. The number of users recently surpassed that of CompuServe, and now numbers about one million.

Prodigy offers over 750 different services and applications, ranging from news and information, online shopping and banking, educational features, and entertainment features. The service costs $9.95 a month for unlimited usage. Unlike CompuServe, advertising is an integral component of the Prodigy service, and is expected to generate the majority of its revenue. Prodigy can be used from most types of home computers. In addition to the services aimed at a national or worldwide audience (which describes virtually all of CompuServe's services), Prodigy offers more regional services such as home banking and local advertising in a number of American cities. Over 100,000 people are using the home banking services, which range from fund transfers, credit card inquiries, mortgages, and loans, to annuity payments. A home grocery shopping service was offered in a few localities, but this proved not to be popular and was recently withdrawn.

Another large segment of the online system marketplace is the business and financial sector. Although the general interest information providers like CompuServe have financial services, they are evidently not comprehensive enough to meet the needs of many business users. The dedicated online financial services typically supply special terminals to businesses on a long-term contract basis, providing commodities and money market information, and online trading services. An exception is Dow Jones News/Retrieval, the system with the largest subscriber base (about 350,000), most of whom use personal computers. It provides current and historical stock quote information and databases of business information. The operators of the Dow Jones service feel that a major impediment to their growth is the difficulty many users have in constructing queries for searching the online full text databases. They have been developing a natural language front end for database queries which they hope will remove this barrier. The Dow Jones service costs users $60 per hour to access.

There are also, of course, numerous noncommercial online services available through a vast array of computer networks ranging from FidoNet (bulletin board systems linked in daisy-chain fashion by dial-up telephone links) to the giant research networks such as the Internet, linked by high-speed dedicated lines and satellites (Quarterman, 1990). Typical services include e-mail, conferencing (usually not real-time), and access to noncommercial databases. One of the best-known conferencing systems is Usenet, which offers hundreds of discussion groups on just about every conceivable topic. The number of participants is unknown, but it probably is of the order of one million. The majority of users access these systems from their local area network (LAN) systems in their workplace.

The online services will not be described in detail here, but we note in passing that for many of the services (private e-mail is a notable exception), broadcasting would be an appropriate and efficient means of disseminating the information. For example, in a conferencing application, when one user posts a message, a copy must be delivered to all of the other participants in that conference. In some situations, it would be highly effective to use a broadcast channel to reach a large user group simultaneously.

A.5.3. Voice Information Services

Owners of touchtone phones have access to services that are unavailable to dial pulse users. When you call a company offering such services (sometimes known as audiotex), a voice will ask you if you have a touch tone telephone. If your answer is yes, the voice will ask you to press a specified button and from then on you can either request directly the information if you know the corresponding code or be guided through menus of a few items. The selection is made by pressing the number corresponding to the selected option and a computer will answer your query with the help of either a voice synthesizer or pre-recorded tapes ("Bell moves...", 1991).

There are numerous examples of databases which can be accessed via telephone lines. Some examples are bus route information (Ottawa, OC Transpo), newspapers like the Ottawa Citizen, or the legal advice service DIAL-A-LAW which is being offered by the Law Society of Upper Canada. These services are provided free of charge to the public.

A major barrier to the potential universality of touchtone services is the continuing existence of large numbers of rotary dial phones. In North America, about 40% of telephones are still of this type, and the percentage is much higher in most other parts of the world. A system has been developed by Northern Telcom for automated operator-assisted calling which can make use of either tone or pulse dialing. It supplements the information it can get from dialing with a speaker-independent voice recognition system which can distinguish yes/no answers to questions it generates by voice synthesis.

A.5.4. ISDN: Integrated Services Digital Network

Volumes of information have been written on ISDN (e.g., Angus 1990; Stallings, 1990); only a brief snapshot will be given. The ISDN network is based on the use of fibre optics. ISDN is divided into ISDN (narrow band) and B-ISDN (Broadband). ISDN will precede B-ISDN by possibly a decade. Basic ISDN service will provide the user with two 64 kb/s data channels and a 16 kb/s control channel. B-ISDN will eventually provide the user with 600 Mb/s or more. ISDN will bring fibre to the curb, B-ISDN will bring fibre into the home or office.

Three types of services are defined by International Telegraph and Telephone Consultative Committee (CCITT): bearer services, teleservices, and supplementary services. **Bearer services** provide the means to convey information (speech, data, video, etc.) between users in real time and without alteration of the content of the message. These services correspond to the lower three layers of the OSI model. **Teleservices** combine the transportation function with the information processing function. They employ bearer services to transport data and, in addition, provide a set of higher-layer functions. These higher-layer functions correspond to OSI layers 4 through 7. Whereas bearer services define requirements for, and are provided by, network functions, teleservices include terminal as well as network capabilities. Examples of teleservices are telephony, teletex, videotex, and message handling. Both bearer services and teleservices may be enhanced by **supplementary services.** A supplementary service is one that may be used in conjunction with one or more of the bearer or teleservices. It cannot be used alone. An example is reverse charging. This can be used to reverse charges on a circuit-switched call or a packet-switched virtual call. Reverse charging can also be used with a teleservice, such as the message handling service, to create a "collect message".

The introduction of B-ISDN promises to revolutionize the world of telecommunications, and of broadcasting, by making available large communications bandwidth, large enough to compete with the cable industry. Field trials are being done all over the world, and commercial applications have started to appear, but home applications are not going to be common in the next 10 years. Once available, it will be possible to bring most communications services (electronic mail, documents, television, radio, videophones, access to databases) to the home by the same medium. B-ISDN will provide capabilities similar to a LAN over the public switched network.

The impact of B-ISDN on medical services could be enormous, making it possible to have access to remote diagnostic equipment, renowned specialists for consultation, more and effective emergency treatment because of not having to describe the situation in a lot of details, just showing it.

European Telecommunications Organizations have agreed to start offering commercial ISDN services in 1992. The services that have been agreed upon are: telephony (3.1 kHz and 7 kHz bandwidth), teletex, telefax (groupe 4), audiographic teleconferencing, videotex (alphageometric and photographic mode), teleaction, videotelephony (2 X 64 kb/s), computerized communication services (call forward, multiple subscribers number, call identification, call waiting, conference call, ...).

Southwestern Bell Telephone in St. Louis, Missouri has tested 45 ISDN applications requested by customers. Most of the applications involve communication from personal computer (PC) to PC or PC to host computer involving voice, data, and video.

The Canadian Government is interested in providing voice and data services to all government departments. This would include 35 locations across Canada and 100,000 phones in the National Capital Region. A Canadian ISDN trial which began in 1987 involved Bell Canada, Government Telecommunications Agency (GTA), Informatics Branch in the Department of Communications and Industry, Science, and Technology Canada and four groups from DND. Currently submissions are being made to the CRTC for new services to be carried on the ISDN network.

Bell Canada has installed fibre trunks across Canada. They are actively installing fibre from these trunks to large corporations. Their plan is to continue this trend by installing fibre to medium-sized business and then small business. Initially business will use narrowband ISDN and try to develop hardware, software, and applications to suit their needs. When narrowband applications are well underway they may switch to B-ISDN and then develop hardware and software to implement broadband applications. B-ISDN applications are expected to begin appearing around the turn of the century.

In about ten years time, a fair number of residential units may be connected by fibre to the fibre trunks and subscribers will possibly utilize some of the business applications and purchase other services from service providers providing applications for the residential market. However, penetration in the residential market will take about another ten years to mature. If Bell Canada were to obtain a broadcasting licence, it is possible that introduction of fibre to the home would be accelerated, but currently indications are that neither standard ISDN nor B-ISDN are likely to be introduced in Canadian homes for at least 5 to 10 years.

A small community close to Orlando Florida is being used to test the future of ISDN; 700 people live and work on what is claimed to be the first ISDN residential application. This ISDN pilot project provides alarm monitoring, medical alert, intercom, control of electric appliances and thermostats, and videotext services such as home shopping and banking, reservations for restaurants, schedules for buses and cable television. The project was started in 1988, and additions were made to handle data and video in the following year.

Since 1979 NTT (Japan) has conducted extensive field trials. In April 1988, NTT began to operate the world's first wide area commercial ISDN basic service INS NET 64, and INS NET 1500 (24X basic service) was introduced in June 1989. Today, INS NET 64 has grown to over 5000 circuits across 150 cities and close to 1000 users, and INS NET 1500 has 82 circuits and 23 users.

There are over 200,000 ISDN access lines installed in the world and this number is expected to reach three quarters of a billion by 1995. Japan and Europe have been the most active in installing ISDN networks. In North America, the availability of both 56 kb/s and T1 (1.544 Mb/s) lines has slowed introduction of ISDN lines since the latter have no clear advantage, while forcing the introduction of new equipment. The fact that equipment of multiple vendors is often not compatible has also been a factor limiting the speed of ISDN expansion, since ISDN standards haven't been finalized by CCITT. The cost of the hardware is for the moment significantly greater than for comparable LAN equipment. As an example, an ISDN board for a PC sells for about $1500 US, while a board to interconnect to a LAN sells for less than $500 US. (See Section B.1.2.4 for further discussion of ISDN)

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APPENDIX B

Current Trends Related to New Broadcast Services

Current Trends Related to New Broadcast Services

B.1. Emerging Transmission Technologies

B.1.1. Introduction

Table 2 summarizes some of the capabilities of various transmission technologies for delivering information services. The primary parameters in the table are bandwidth, in terms of data rate capability, and whether a return channel exists. This obviously does not tell the whole story, since there are many other attributes which are important. Also, some technologies, such as satellite distribution, are very hard to characterize in this manner since there is a wide range of options available. Nevertheless, the table does convey some idea of the capabilities that different transmission systems have to offer. The table does not include physical media such as CD-ROM, but it does include both broadcast and non-broadcast forms of electronic delivery, including some which have only reached the field trial stage.

B.1.2. Services to Fixed Locations

B.1.2.1. Cable Delivery

For services to the home, the most important trend in transmission systems is the continuing penetration of cable, and the upgrading of cable systems to provide more bandwidth and new services. Three-quarters of Canadian households with TV are already connected to cable, and to the younger generation, a cable connection is now considered to be as basic a requirement for living quarters as a telephone connection. Current cable systems have bandwidth ranging from 300 MHz (37 channels) to about 400 MHz (54 channels). In the next few years, we can expect to see more "fibre-to-the-feeder" (or "fibre-to-the-neighbourhood") upgrades which extend the bandwidth significantly. The first of these upgrades in Canada, by Rogers Cablesystems in the Toronto area, will extend their system to 550 MHz bandwidth and 77 channels. Even with existing systems, it is relatively easy to use them for the transmission of digital data, as evidenced by the 4 Mb/s Videoway channel.

It is likely that other Canadian cable operators will follow Rogers' lead and take a fairly cautious incremental approach to upgrades. The higher-end upgrade possibilities are illustrated by the system in Queens, New York, where the use of fibre trunks will extend the useful bandwidth to about 1 GHz, bringing the capacity to around 150 channels. Many of the new channels are expected to be used to carry multiple video channels, by means of digital compression technology. It is now considered feasible to carry 4 video channels with acceptable quality in the standard 6 MHz NTSC bandwidth, and this number is likely to continue to increase. These developments will push the total number of channels available on such systems to well over 300. It will probably be close to the end of the decade, however, before cable systems with this capacity are widely available in Canada.

Table 2 - Summary of Transmission System Capabilities			
Channel	Raw bit rate bits per second	Data flow	Status
Wireless			
Cellular phone	Up to 9.6 K	Two-way	in place
FM subcarrier(1)	1.2 K to 19.2 K	One-way	in place
PCN (2)	?	Two-way	future
VBI (1)	Up to 150 K	One-way	existing but not much used in North America
Satellite (3)	75 to 2 M	One-way Two-way (6)	in place
DAB (4)	Up to 4 M	One-way	future
Wired			
Standard telephone	1.2K to 19.2K	Two-way	in place
ISDN BRI PRI	 64 K 1.54 M USA 2.05 M Europe	 Two-way	 limited services future
T1	1.5 M	Two-way	business
Cable (5)	300 M to 1 G	One-way Two-way (7)	in place limited services
T3	45 M	Two-way	limited avail.
B-ISDN	155 M to 620 M	Two-way	future

(1) Reliability and coding influence usable bit rate significantly
(2) Personal Communications Network - depends on implementation
(3) Depends on specific implementation
(4) Based on a 4 MHz bandwidth and all channels used for data. It is expected to be shared with audio programs
(5) Capacity of coaxial cable - between 40 to 150 TV channels
(6) It is still expensive to have two-way communication for satellite and in consequence a number of services provide only one-way connection. The bandwidth is not necessarily symmetric for two-way communication by satellite
(7) Most cable operators do not currently provide uplinks; when it is offered it consists of a small bandwidth shared by many subscribers

The coming cable upgrades, which are essentially aimed at reducing the number of amplifiers between the head end and the subscriber, will also facilitate the use of the systems for two-way interactive services. The available return bandwidth will still, of course, be shared by many subscribers, and the potential applications therefore are more limited than in a switched broadband system such as B-ISDN (Broadband Integrated Services Digital Network). However, many interesting applications do not require a large uplink bandwidth, and the opportunity will be there to develop new services around them. Two-way interactive services can, of course, also use other uplinks such as the telephone network, and need not await the upgrading of the cable system.

B.1.2.2. Satellite Delivery

The other significant development in delivery systems during this decade are the high-power Ku-band satellites which are able to deliver good-quality video to ground stations with very small aperture terminal (VSAT) antennas (dishes less than one meter diameter). With the first North American Direct Broadcast Satellite (DBS) service to use this technology scheduled to go on the air within months, it will be interesting to see if an expected price tag in the $1000 range will be low enough for such television service to gain wide acceptance, considering that much of the programming will be pay-per-view. It will also be interesting to see whether DBS can make inroads into areas which are already cabled, by virtue of offering more attractive programming packages (such as near-video-on-demand, i.e., multiple showings of popular movies with staggered starting times) before the cable companies are able to. This seems unlikely to happen, given the cost (compared to video rentals) and the fact that cable companies will be able to use the same compression technology that enables DBS services to offer many more channels than was previously possible with analog TV. The DBS systems have a window of opportunity by getting there first, but that may not be enough to overcome the economic factors. In any case, DBS clearly has an important long-term role to play in reaching that portion of the population who can never be economically connected to cable or fibre. Satellites, of course, have been of importance in business applications for a number of years. They form much of the backbone for broadcast network distribution.

B.1.2.3. Terrestrial Broadcasting

The use of terrestrial transmitters to disseminate information to fixed locations can be expected to diminish in importance as those locations become increasingly wired into the cable and telephone systems. One application that will be important for some time to come is datacasting using the vertical blanking interval (VBI) of television signals. VBI offers a fairly high data rate (up to 150 kb/s or so) and is an efficient and timely means of distributing data to a number of points simultaneously. There are, of course, other VBI applications such as closed captioning which are not related to the type of transmission medium used.

B.1.2.4. The Evolving Telephone Network

There is a great deal of activity focused on ISDN in the telephone industry. but it does not appear that it will be a major factor in home services during this decade. The uplink for most interactive services will continue to be the conventional telephone network, possibly supplemented by uplinks via cable as the upgraded systems arrive. The continuing fall in modem prices should make 9600 bps the "standard" rate for accessing online services soon (telephone modem prices have fallen by more than an order of magnitude in less than 10 years), and new standards for data compression can now provide throughput rates which are up to four times higher than this. This rate is quite acceptable for many applications involving text and simple graphics. One shortcoming of this method for accessing services is that it is shared with normal telephone usage, and many people may not want to pay for a second line which could be dedicated to data transmission. The main attraction of basic ISDN service is not so much the higher data rate but the fact that it will offer simultaneous data and voice services. It appears, however, that the tariff for basic ISDN will be considerably higher than for a conventional subscriber line, perhaps close to the cost of two such lines, thus cancelling much of the advantage. ISDN users will also have to discard their modems and invest in new ISDN interfaces for their computers, and these interfaces are currently very expensive. For their part, telephone companies do not see much demand for narrowband ISDN services to the home. It is entirely possible that basic ISDN service may never appear in Canadian homes in any significant numbers, as many people in the industry are already looking beyond it to B-ISDN.

Narrowband ISDN service is available to businesses in a few places, and it seems destined to have more impact in the business sphere than in the home. However, it does seem to have acquired a "too little, too late" reputation, and many business requirements for data rates have already been satisfied by existing services (i.e., 56 kb/s lines, and fractional T1 lines up to 1.5 Mb/s).

B.1.3. Mobile Services

B.1.3.1. Terrestrial Delivery

Digital information services for specialized applications such as paging, police and taxi dispatch have been with us for several years, but services for the general public are few and far between. With a portable computer, voiceband modem, and cellular phone, one could reach an online service from a vehicle, but that represents the extent of the capabilities available at this time. In some places, information aimed at motorists is carried on subcarrier signals of FM broadcast services, most notably by the RDS system in Europe. It seems quite likely that RDS will appear in North America in the next few years, but it has very limited capacity to provide services beyond its original intended purpose, which was to facilitate the automatic tuning of broadcast receivers.

With the analog cellular system now well established, many initiatives are now under way towards all-digital mobile telecommunications systems, which will facilitate the transmission of other types of information in addition to voice. There are two basic paths being pursued: one towards a full-fledged digital cellular system similar in many respects (e.g., cell sizes) to the current analog system, but with enhanced capabilities such as highly secure speech scrambling; and the other towards cordless telephones with limited coverage. The main distinguishing feature between the two systems is that the cordless telephone system lacks the capability to hand off calls when the user moves out of the range of the base station used for call establishment. Both paths are expected to merge into a microcellular PCN (Personal Communications Network) system offering highly compact portable/mobile units and unrestricted mobility via full handoff capabilities.

In terms of accessing new information services, it is not clear at this time what data rates the future PCN system will have to offer. Given a fixed bandwidth available for PCN, there will be a tradeoff between the cell size (and hence the number of users in its coverage area) and the bandwidth which can be made available to individual users, so that economic considerations (cost of implementing smaller cells vs. revenue derived from offering higher-bandwidth services) will ultimately determine the limits. Some systems now on the drawing boards include demand assignment schemes so that the system can dynamically allocate more of the total cell bandwidth (if available) to users who require it. This makes it hard to assess the future capabilities of such systems, but it seems reasonable to assume that service equivalent to basic ISDN will be available to mobile users.

Future PCN services can easily absorb services such as paging and dispatch which are separate today, but how will they relate to broadcasting? Can all mobile information services be integrated under the PCN umbrella, in a manner analogous to that intended by B-ISDN for fixed services?

Digital Audio Broadcasting (DAB) represents the next generation of broadcasting which will be aimed primarily at mobile and portable users. Some people are calling the service simply Digital Radio, since it can and will be used to transmit data other than audio. Although the early plans for its rollout tend to envisage transmission from wide-coverage transmitters similar to today's FM broadcasting (or from satellites, or both), in principle there is no reason why it could not be deployed as a microcellular system. There is also no technical reason why both broadcasting and mobile telecommunications systems could not share sites, transmitters, and other facilities. This would be advantageous for the user, since it would allow the receiver for all mobile services to be unified into one box, with one antenna. At the present time, however, separate parts of the spectrum are being sought for PCN and DAB services, and the proposed schemes have quite different transmission systems. Thus the prospects for integration of all mobile services appear dim. If we could begin with a clean slate in allocating spectrum, it would be more feasible to allocate a large contiguous block for mobile services, but this is not likely. It seems that PCN and DAB will continue to evolve along separate paths for the time being (resulting in, unfortunately, higher costs for the consumer).

There is little doubt that broadcasting will continue to be an important factor in mobile information services for many years to come. Mobile services require some portion of a very limited spectrum, and broadcasting is a very efficient means of allowing many users to share this limited resource. The disadvantages that accrue from the synchronous and nonselective nature of broadcast information can be overcome to a large extent by means of intelligence (software filters) and local storage at the receiver end. Mobile services will never have quite the same "programming on demand" delivery capability as will fixed fibre-based networks, because of the scarcity of spectrum. Eventually, however, the distinctions between fixed and mobile services may tend to blur as the fibre distribution system sprouts smaller and smaller radio frequency (RF) microcells, and the bandwidth available per user continues to rise. The total bandwidth for mobile services should also increase as fixed point-to-point services (and perhaps some broadcast services) migrate from RF to fibre. The next generation of mobile services beyond DAB and first-generation PCN, perhaps beginning around the year 2020, may then fulfil the promise of truly ubiquitous ISDN access.

B.1.3.2. Satellite Delivery

Satellites have been an important factor in long-range marine communications for a number of years. More recently, satellite-based systems such as OmniTracs have found applications in fleet management, especially in the long-range trucking industry. However, the antenna and other transmission equipment needed to access a geostationary satellite tends to rule out most applications involving passenger vehicles or handheld portable systems. Satellite delivery is being considered for DAB, however. In this case, it would be a hybrid system, with terrestrial transmitters covering urban and other heavily shadowed areas, and the satellite covering the open areas.

There are also possibilities, such as Motorola's proposed Iridium system, that would make use of satellites in low earth orbits, making them accessible with more modest equipment. If such systems materialize, they will support PCN-type services, and may be of interest for some mobile information applications, but they are not applicable to broadcast services.

B.2. Interactive Multimedia Technology and Broadcasting

B.2.1. Introduction

Viewers have been able to change stations on television for many years, but interactivity is now increasing as the number of channels available increases and features such as picture-in-picture are available. Users now have more control over what they view on television, and it seems to be popular.

Disk-based physical distribution media, such as CD-ROMs and videodiscs, are providing consumers with still further interactivity. Users can control the information viewed and listened to in detailed ways. These disk-based media are thus creating another service that will take the audience away from the traditional spots in front of TV and radio. CD-ROMs with interactive programming are just now beginning to hit the mass market. From the consumer's point of view, it is still expensive to acquire CD-ROMs: about $1000 for a computer with player and the CD-ROMs themselves retail for $50-$100 depending on the content. We expect that these costs will reduce substantially within the next 4 years.

Interactive multimedia technologies are at the point where broadcasters could take advantage of them. Broadcasters have production facilities which could be turned to the production of interactive multimedia products distributed on CD-ROMs. Some of the information produced this way could be used in new broadcast services or for existing broadcast programming. The kind of positive relationship we have seen between air time and recorded music sales might well be duplicated if broadcasters program with their multimedia products. As well, broadcasters could use interactive multimedia productions as a basis for hybrid broadcast services in which a consumer uses a purchased CD-ROM disk, which provides historical information, together with the broadcast program which provides the more current information.

B.2.2. Engineering Issues

Currently, most broadcast technologies are being delivered to the home in analog form, and they are being stored in analog form (e.g., VCR, audio tape). We are in a transition phase and eventually it is expected that most materials will be in a digital format. Having material in digital form brings new problems and opens up new possibilities. Sound and video, once in digital form, can be manipulated and transformed much more easily and securely. It becomes possible to scale, combine, or alter existing materials.

Digital technology also brings a new set of problems; most importantly, the large amount of data required to encode video and sound. To transmit (in real time) or store uncompressed high quality stereo audio requires around 1.5 Mb/s, and uncompressed full motion colour video requires around 240 Mb/s. For these reasons, research in compression techniques is on-going and products offering compression ratios of up to about 8:1 for high quality stereo sound and 20:1 for video have been developed in which the output is virtually indistinguishable from the original. Much higher compression ratios, especially for video, are achievable when some noticeable degradation of the original signal is acceptable. For example, the Intel DVI technology achieves about 100:1 compression on video, and others have claimed ratios as high as 500:1. Compression techniques will be a very important key to the success of multimedia technologies in digital form.

Multimedia presentations need cheaper high quality displays for text and graphics than are currently available. Current NTSC TV is not an effective display for multimedia presentations; displays of text and graphics on TV sets are generally of low quality. Most home computer displays are superior for these purposes. High resolution displays are being used now by some companies to display high-end computer graphics productions; however, the high price of these displays will make them impractical for consumer multimedia products until near the end of the century. Ideal would be inexpensive flat panel displays, some of which are appearing in laptops and in Data Diskman, a product from Japan which will be marketed in North America this fall. Larger flat panel displays may well appear by the middle of this decade; the Japanese have a research program scheduled to find a solution to this problem by 1996.

Multimedia systems also need better storage devices. CD-ROMs and videodiscs are available as consumer products but are not writable. Write-once (WORM) and read/write optical disk drives are just beginning to enter the consumer marketplace.

The engineering issues of multimedia systems are being well addressed by many researchers and vendors, and many products are already available. The main concerns of broadcasters in making use of multimedia tools would be related to standards and compatibility with broadcast equipment, and how to design multimedia programming which is suited to the broadcast infrastructure.

B.2.3. Human Factors Considerations

The human factors design of interactivity is crucially important to the success of interactive multimedia productions. There are still many problems in this design in the disk-based productions we have seen. Users get lost and don't find the information they want, or they don't know what information is available, or they don't know what to do next, or the information is not presented as the user would like it to be. The user interface is definitely not transparent; that is, the user must think about how to use the system and is not able to forget that and to concentrate on the information or communication with someone else. Transparency will take time to achieve with multimedia technologies, both in the systems created for the consumer to receive information, and in systems developed for the producer to create programming.

There are no standard methods for design of the user interface. There are methods of development of user interfaces though, and these methods are familiar to the Broadcast Technologies Research Division. Productions would need careful human factors design to ensure their success.

B.2.4. Other Issues

From the producer's point of view, development costs are still high, but they are decreasing. For CD-ROM distribution, there are still several platforms on which to present multimedia productions, the most common being the IBM-PC, Mac, and TurboGraphics. This is becoming less of a problem, however, because there are ways of making one production which can be ported with little cost to most of the major platforms. Once a production is complete, the cost of reproducing CD-ROMs is about $2.00 per disk in any quantity. The low cost should make CD-ROMs attractive to broadcasters as an alternate or supplementary form of program distribution.

Applications software was given a large boost by the creation of Hypercard, Apple's software which allows for creation of stacks of textual information, like boxes of cards, where the user can navigate from one element to another in the stack. This concept has now been used by several developers to create hypermedia software which serves the same function but can incorporate any medium, including text, graphics, video, still pictures, and audio. There are still problems in producing with hypermedia software, however. How to use production tools is not obvious to the uninitiated creative person, and the user interfaces need better design.

One of the major problems in creating multimedia products is copyright. Producers have trouble getting clear access to the large volume of information they want to use and then they want to manipulate it in ways which may not suit the creator.

B.3. Virtual Worlds Technology and Broadcasting

One of the emerging technologies which has the highest profile is the virtual worlds technology.

B.3.1. State of the Technology

In practice, virtual worlds technology means putting on a pair of eyephones, earphones, and a dataglove in order to participate in the illusion of a three dimensional world which may be explored and manipulated. All of the virtual worlds that have been created so far have been unpopulated, except for the occasional bird or fish. Eventually more than one person will share a virtual world. However, this requires solving some additional problems in generating three-dimensional models.

If two people share a virtual world, a three-dimensional model of each person would be displayed in the virtual world. No one has yet considered how to represent movements of these models. The obvious solution, fitting each person with a full body suit and having the model move in the same way as the person's body, may or may not be satisfactory.

B.3.2. The Interface Technology

The term "eyephones" has been coined to describe a device which places a pair of tiny monitors in front of someone's eyes. They are typically either very light-weight CRTs or, more commonly, liquid crystal displays. When wearing the eyephones, the user can turn in all directions and still see an image. If the display is not worn, but is in a fixed position, like a television set, the person will not have the illusion of entering a virtual reality, but will, at best, have a window onto another world. At worst, they will have a moving picture of another world, no better than an existing television program. Eyephones also include a device which reports the location and orientation of the person's head. The computer must know where the person's head is pointed in order to generate images with the correct view.

The term "dataglove" is used to describe a glove which senses the position of the hand and fingers. As well, an important part of the interface technology is stereo earphones. These are normally mounted on the same harness as the eyephones.

B.3.3. Simulating a World

In order to simulate a three dimensional world, objects must be modeled in a computer. These objects include both visual objects and sounds. The objects must have a stable location in three-dimensional space. Thus, a stereoscopic view must be generated, one for each eye. As the person's head moves, all objects must move in exactly the opposite direction in the eyephones and earphones so that their position appears constant.

A person is normally given the ability to fly through the virtual world by pointing with the index finger in the dataglove. In fact, typically, a number of different hand signals allow flying forward or backward in any direction, and instantaneous translation to another location. As well, a person may grasp objects in the virtual world by grabbing them with the hand in the dataglove.

B.3.4. A Variety of Technologies

There are a wide variety of different systems being demonstrated. Each has somewhat different characteristics. No single system has all the features required for a complete simulation of a virtual reality.

B.3.4.1. The VPL Technology

The most common virtual world interface is the VPL Research Inc. (VPL) eyephones and dataglove. The VPL eyephones consist of two coloured liquid crystal displays and the requisite optics to allow the eyes to focus comfortably. A position sensor (called a Polhemus Sensor after the manufacturer) is placed on the top of the head.

The VPL dataglove consists of a fabric glove with optical fibres attached to the back of each finger. As the finger bends, the optical fibres flex and lose their efficiency in transmitting light. A Polhemus position sensor is attached to the back of the hand. There is no provision for any tactile feedback; the VPL dataglove is strictly an input device.

In order to provide enough computational power for the VPL system, three computers are required. Two Iris graphics workstations, one for each eye, compute the scan conversions for the visual images; and a MacIntosh personal computer accepts the inputs from the dataglove and generates the polyhedrons which compose the world.

B.3.4.2. Military Simulators

The first (and most costly) virtual reality systems were developed by the American Air Force as a means of testing the design of a more effective cockpit for the next generation of fighters. Because the pilot is already wearing a flight helmet and because his position is constrained by his harness and seat, much more elaborate displays may be used which provide much higher resolution images. Early advanced cockpit designs provided for the virtual images to overlay the pilot's vision, so that he saw the real world enhanced by the virtual world. More recent designs eliminate the outside view completely so that the pilot only sees and flys in a virtual world.

B.3.4.3. Custom Research Systems

Currently the most innovative virtual reality systems are found in research laboratories in universities. A wide variety of systems have been developed for test, which include such features as tactile feedback in gloves so that the person wearing it can receive a sensation of texture when a virtual object is touched; force feedback so that a person meets resistance when touching a virtual object; and even treadmills so that a person can physically walk through a virtual space.

B.3.4.4. Nintendo Peripherals

Lest anyone come to the conclusion that virtual worlds are expensive laboratory curiosities, it must be noted that Nintendo video games can be augmented with a variety of devices which have passed directly from the virtual reality laboratories to the toy store shelves. The premier example of this is the Nintendo Power Glove which uses the same fibre optic technology as the VPL Dataglove. Sitting in front of a home television set, a video game player can grasp or strike objects appearing on the screen. While the player is, in fact, waving his hand in front of the screen, it is surprisingly easy for him to acquire the perception that he is manipulating an object behind the screen. The Power Glove costs about $100.00.

As well, Nintendo has developed a helmet which has a red cursor projected onto a half-silvered mirror in front of the player's right eye and a voice activated switch. The player can select objects on the screen by turning his head so that he is looking at the object and speaking a word.

Nintendo is also selling a pressure-sensitive mat so that the player can issue commands to the video game by moving his feet and shifting his weight.

As well, electronic shutters are available for some computer games. Goggles containing liquid crystals are linked to a display, such that each eye is exposed to alternate frames. Thus, each eye receives its own 15 Hz image, combining to form a true stereoscopic animation.

While the sum of these video game peripherals is not sufficient to produce the three-dimensional virtual world found in laboratories, they do demonstrate two very important principles.

First, virtual reality component technologies can be developed and sold for a reasonable price.

Second, there is sufficient consumer demand for these capabilities to return a profit.

B.3.5. Subjective Impressions

It is impossible to adequately describe a virtual world in sufficient detail in a written report to substitute for the actual experience. However, it is possible to describe the conclusions drawn from the experience acquired at the 1991 Virtual Worlds Symposium, previous conferences, and in a number of laboratories that have been visited recently.

Virtual reality technology really does allow one to feel that they have entered a virtual world. The world does not have physical substance, but it does have form and order. There are places and objects in this world and these places and objects obey a set of laws which is similar to the physics of the real world. There are three dimensions. Up and down are significant directions, in that it is difficult to turn oneself upside down.

However, there is no time when a person would mistake a virtual world for the real world. In part this is due to the difference in physics between the virtual world and the real world, and in part this is due to the poor perceptual quality of the virtual world. The virtual world is grainy in appearance, simple in form and slow to react to the user.

B.3.6. Virtual Physics

In the virtual world, gravity is not as important as in the physical world. You can float at any location in the world without effort, and can fly with ease. Objects can be seen and heard, but they are not substantial. It is possible to fly through any object, including the ground. Flying through an object reveals it to be a paper-thin shell with empty space inside.

There is also the knowledge that any of these rules may be changed at will. For example, a spinning banana which is floating in the air may not stop spinning when grasped, leaving you feeling like a baton twirler. A top hat sitting on the ground may instantly transform itself into a bouquet of roses when grasped, then transform back to a top hat when released.

B.3.7. Virtual Perceptions

There is considerable room for improvement in perceptions provided by the virtual world technology.

The VPL eyephones provide much lower spatial resolution than the eye can perceive. In fact, they provide lower resolution than NTSC television. Although the world is coloured, surfaces appear grainy. Not only do the liquid crystal displays have a lower resolution than a CRT, they have also been magnified so that each display covers a much larger visual angle than a CRT. In order to convey the impression of a complete world surrounding the viewer, the display has been extended into the periphery, at the cost of good resolution in the fovea, the sensitive center of a person's visual field.

The Iris graphics workstations which drive the displays provide a much lower temporal resolution than the eye can perceive. In fact, depending on the complexity of the images, the displays are refreshed between five and ten times per second. This does not lead to flicker, as one might first expect, because images are not presented momentarily, but persist until the next image is available. However, it does lead to jerky movement and to lags in the response of the system to the user's inputs.

Even to achieve animation rates exceeding five frames per second, the objects in the world must be very simple, and therefore, very unrealistic. The visual objects generally consist of hierarchies of coloured polyhedrons which are transformed over time. For example, a bird is a blocky body which moves through space and blocky wings which move up and down relative to the body.

B.3.8. Implications of Virtual Worlds Technology

The implications of this technology arise from the concept that virtual reality allows a person to wear a computer, rather than viewing computer-generated events from outside. A computer user need not be limited to a small window on the events generated by the computer, but can be surrounded by them.

Wearing a computer implies a user interface with a much higher bandwidth than traditional computer interfaces. Whereas the traditional computer interface is limited to a keyboard and a low-resolution monitor, information channels a few kilobits per second, the bandwidth of the human interface with the physical world is many orders of magnitude higher. The human visual system has an input capacity between ten and a hundred gigabits per second. The capacity of the human auditory system is between ten and a hundred kilobits per second. The capacity of the human skin to absorb information is between a hundred and a thousand megabits per second. As well, there are a number of other sensory systems which receive information such as proprioceptive feedback from muscles and acceleration. There is no question that a human being is capable of emitting and receiving much more information than current computer interfaces can deliver.

Virtual reality interfaces are not inherently limited in their capacity. Given a sufficient amount of computational power, the virtual reality interface is theoretically capable of approaching the capacity of the human sensory systems. More important, virtual reality interfaces are designed to take advantage of the natural, intuitive capabilities of human beings. Moving an object by moving a mouse while depressing a button is much less natural than grabbing a three dimensional object with your hand and pulling it into position. In order to take advantage of computationally powerful user interfaces, the user will have to be able to use the techniques that have been learned from the cradle. There are limits to the degree to which people can retrain their perceptions and reflexes to accommodate artificial user interfaces, such as keyboards and foot pedals.

B.3.9. Current Commercial Applications

Most of the current applications of artificial realities stem from the ability of virtual reality interfaces to provide three dimensional views of objects which cannot be seen in the physical world. There are a number of reasons why objects may not be visible in the physical world.

People may want to see objects which do not exist. For example, Boeing is currently designing the Boeing 777 aircraft. For the first time, the aircraft is completely encoded as a digital data set before construction is begun. This allows Boeing to simulate different configurations of seats and cargo to ensure that everything fits properly. It allows them to place virtual models of mechanics around the aircraft to ensure that maintenance hatches are properly positioned so that critical parts may be seen and replaced if necessary. And it allows them to get feedback from potential customers before irrevocable design decisions are made.

People may want to see objects which are too small or too large to be perceived with the naked eye. Virtual reality technology may be used to allow people to explore the surface of VLSI chips, to fit molecules of enzymes and proteins together and to see very large astronomical structures.

People may want to see objects which have a different mode of perception than normal. For example, NASA has transformed data describing the fuel flow from the fuel tanks into the engines of the space shuttle booster rockets into a virtual object. Engineers can now see the fuel flow from any angle, as though it were a separate object.

People may want to see objects which do not exist at all. For example, virtual realities allow statistical trends to be graphed in three dimensions, and those graphs imposed upon another object. Epidemiologists can see disease vectors flow across the country in a virtual reality.

People may want to see objects that other people do not see. During an operation, the anesthesiologist would like to see the patient's vital signs and the monitors displayed next to the patient. The surgeon, on the other hand, would like to see a three dimensional CAT scan displayed next to the patient. Neither doctor wants the other information obscuring his own view.

And people may want to see objects from a different perspective. High school students learning about forest management may be able to see a forest from the perspective of a tree, a fish or a bird.

Currently, there are a number of applications being developed in the areas of engineering, scientific visualization, medicine and education. Virtual reality researchers have discovered that they cannot imagine a sufficient number of applications. Rather, they find new applications by publishing descriptions of the technology and letting experts working in other areas consider whether they have an application or not.

B.3.10. Broadcast and Virtual Worlds Technology

This raises an immediate question for us. Having learned about virtual realities, are there applications in broadcasting for these technologies?

There are two different categories of applications possible in broadcasting: developing virtual reality programs for broadcast to consumers, and using virtual reality technology in new studio tools to help television producers make television programs.

B.3.11. Virtual Reality Programs

The most obvious application is in the development of programs for the consumer. Considering Nintendo's positive experience with the sale of virtual reality technologies to consumers, we must ask if broadcasters will soon be forced to compete by providing virtual reality programming for consumers. Will our broadcasters have to allow viewers to walk around virtual sets rather than simply sitting outside, watching a moving picture?

To answer this question, we must compare the costs and benefits for the consumer.

First, the technology is expensive. While a data glove can be made for a low cost and eyephones will eventually be available for a moderate cost, powerful computers are required to calculate the images. While the cost of computation will decrease dramatically in the medium-term, computers which are powerful enough to support virtual reality will not fit in the average consumer's budget for a long time. Five years from now, these machines will still cost many thousands of dollars.

Second, considerable communication bandwidth is required. In order to broadcast virtual realities, three-dimensional models of the virtual reality must be broadcast, not just a simple single-perspective view. While simple worlds composed of a few polyhedra would require very little bandwidth, a world which is sufficiently interesting to attract a large audience over a long period would require transmitting a very complex three-dimensional model.

Third, the user interface exacts a high social cost. In order to enter a virtual reality, a person must wear eyephones and earphones which isolate him or her from other people. A family cannot enter a virtual reality together, but could only, at best, encounter virtual images of each other within the virtual reality. It seems unlikely that people would be willing to isolate themselves from each other unless the information offered was much more compelling than that which is currently available through traditional broadcast media.

These high costs must be compared to the benefits. Unfortunately there are few benefits. While it is true that entering a virtual world is more engaging than just watching a moving picture on a CRT, it is not that much more interesting. This is particularly true of the rather simple worlds that we are currently able to simulate with existing computers.

In order to get definitive answers to these questions, considerable behavioural research must be conducted. An extensive field study would be required to measure the costs of using an interface which isolates people from other people in the same room and to measure the relative preference for virtual realities over existing movies and television programs. Currently no one is conducting such studies, primarily because their cost is very high and, considering the current state of the art, money is better spent developing the technology rather than evaluating it. No one really wants a detailed evaluation until the technology has been developed as much as possible.

B.3.12. Studio Production Tools

The other obvious class of applications for virtual reality technology for broadcasters is in the development of tools for television production. If virtual reality technology can be used to make better aircraft, space shuttles and medical operations, why not use it to make better television programs? It should not be surprising that Alias Ltd., Canada's only surviving company capable of producing special effects for television and movies, is working with virtual worlds technology.

It is easy to imagine a system which lets a television producer see and modify a sound stage before it is actually built, design a costume or even select a short list of actors before holding auditions. It is equally easy to imagine a virtual simulation of the cable network in a city. A cable engineer would be able to fly about the simulation, connecting and disconnecting different trunk lines or adding concentrators, all the while watching a three dimensional graph of the capital and operating costs of the different configurations.

B.3.13 Conclusions Regarding Virtual Worlds Technologies and Broadcasting

Virtual worlds technologies could be useful to broadcasters, but considerable research would be required to design applications which are cost-effective. The Broadcast Technologies Research Branch is not proposing to conduct this research in the current program. Our role will be to monitor the progress made in these technologies and to advise the broadcasters of their potential as possible applications appear to be closer to fruition.

APPENDIX C

List of Contacts

List of Contacts

Organizations and Individuals Visited (External to COM):

Alberta Research Council, Calgary, Alberta
  Advanced Computing Technology Department (Ernest Chang)
Alberta Government Telephones
  (Roger Pederson)
Alias Research, Toronto
  (Martin Tuori)
Apple Computers, San Francisco
  Multimedia Lab (Nick Robins)
Bell Canada, Ottawa
  Government Relations (Liz Ostiguy)
Canadian Broadcasting Corporation, Toronto
  (Jean-Claude Tanguay)
Canadian Workplace Automation Research Centre, Laval, Quebec
  Integrated Systems Engineering (Raymond Descout)
Centre for Image and Sound Research, Vancouver
  (Martin Gotfrit)
Defence and Civil Institute of Environmental Medicine, Toronto
  Human Factors Division (Martin Taylor)
Digital Art Productions, Ottawa
  (Ken Billings)
Discis Knowledge Research Inc., Toronto
  (John Lowry)
DVS Communications, Ottawa
  (John Kelly)
Hewlett-Packard Canada, Ottawa
  (Katherine Bradford)
Interactive Image Technologies Ltd., Toronto
  (Joseph Koenig)
Magnus Communications Design, Vancouver
  (David Morgan)
Microtel Pacific Research, Burnaby, B.C.
  Advanced Technology Group (Richard Beaton)
Ministry of Transportation of Ontario, Toronto
  Transportation Control Technology and Systems (Gabe Heti)
MIT Media Lab, Cambridge, Mass.
  (John Hynes)
MIT Laboratory for Computer Science
  (David Gifford)
Nexus Display Systems, Burnaby, B.C.
  (Alan McInnes)

Reflections Video Productions, Ottawa
(Bob Manser)
Rogers Broadcasting, Toronto
(Steve Edwards)
Rogers Engineering, Toronto
(Donald Monteith)
Simon Fraser University, Burnaby, B.C.
EXCITE Lab (Gerri Sinclair)
Simon Fraser University, Burnaby, B.C.
Centre for Systems Science (Nick Cercone)
The Banff Centre for the Arts
(Dan Thorburn)
Transport Canada, Ottawa
Policy and Coordination (Arjan Chandan)
TVOntario, Toronto
(Olga Kuplowska)
University of Alberta, Edmonton, Alberta
Computing Science Deptartment (Mark Green)
University of Ottawa, Ottawa
Electrical Engineering Department (Morris Goldberg)
University of Toronto, Toronto
Computing Science Research Group (Marilyn Mantei)
Vidéotron, Montréal
(Michel Dufresne)
York University, Toronto
Mass Communications Studies (Jerome Durlak)

Conferences and Symposia Attended:

ACM SIGGRAPH 91 (Las Vegas)
ACM SIGCHI 91 (New Orleans)
Canadian IVHS Seminar (Ottawa)
First National Datacasting Symposium (Toronto)
IEEE Consumer Electronics Conference (Chicago)
Industry Symposium on Virtual Worlds (Seattle)
International Joint Conference on Neural Networks (Seattle)

THE CHANGING FACE OF BROADCASTING:
RESEARCH PROPOSALS FOR NEW
BROADCAST SERVICES

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