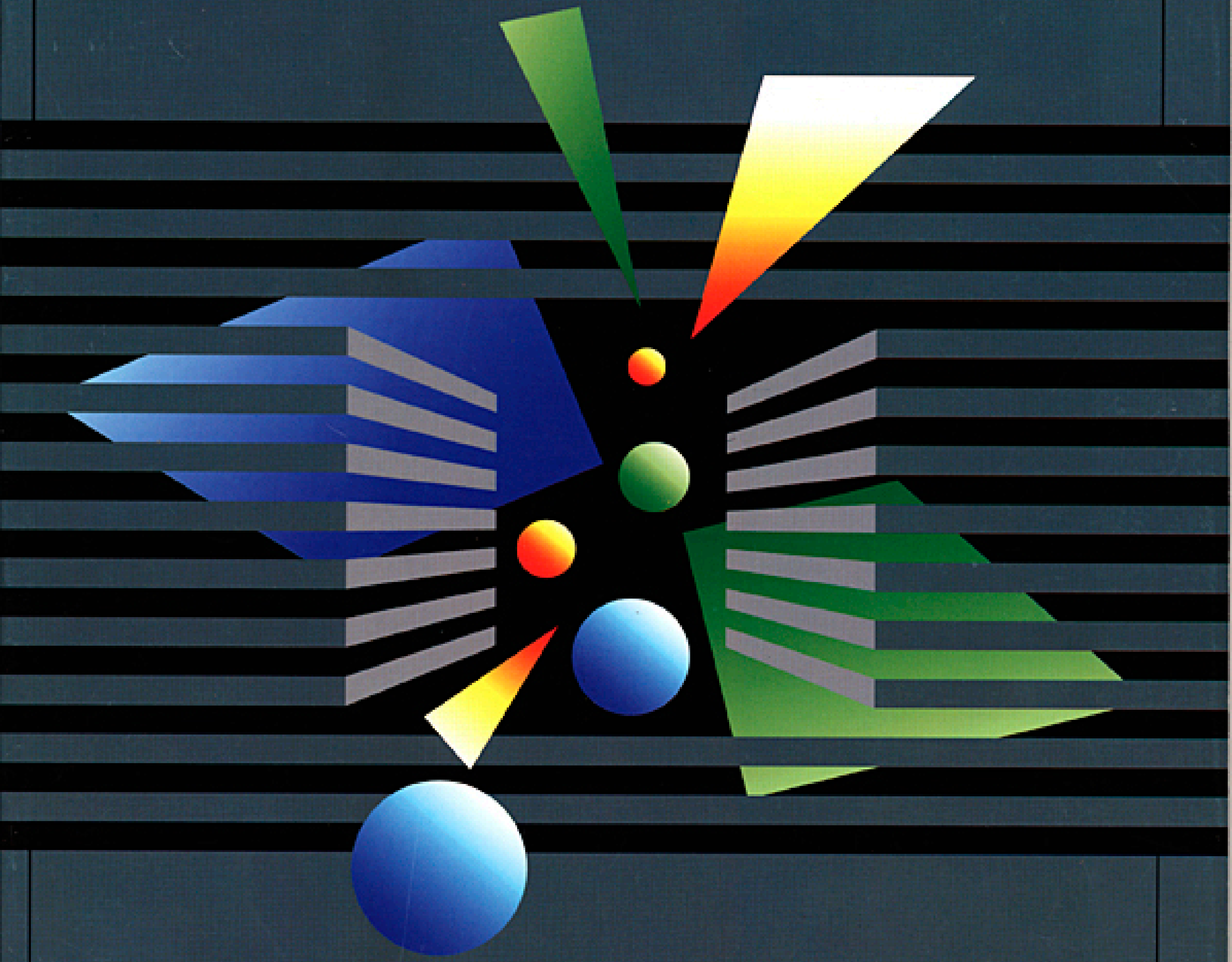
Telektronikk 4.93

Cyberspace



Contents

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BY HÅKON W LIE

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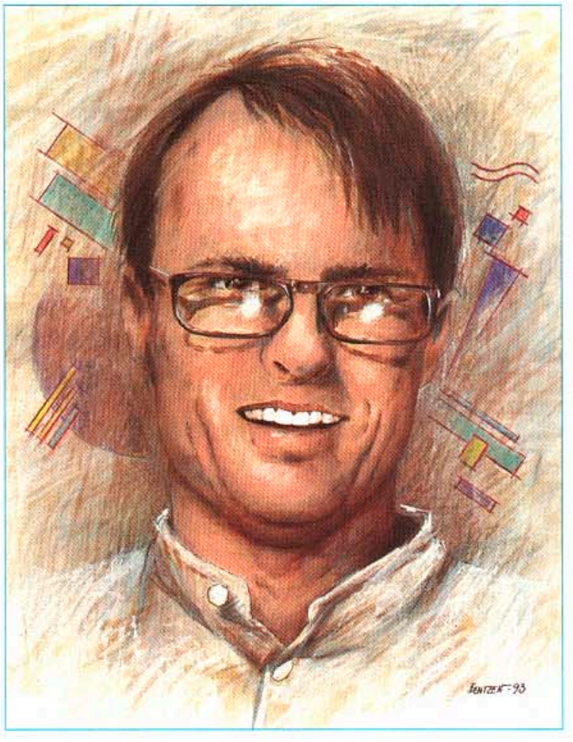

This issue of Telektronikk will discuss the emerging global computer network, its inhabitants, its content, and the industries that will converge there.

The title of the issue – cyberspace – is borrowed from a hard core science fiction novel. Most readers have probably seen the term at some point, but perhaps not from a telephone company. Some readers may find the source of inspiration a bit disturbing. The disturbed reader does not expect literary references in Telektronikk, and may argue that valuable contributions in this journal should have a stronger foundation than what a subculture of science fiction can offer. Those who think this way may want to remind themselves of the fact that one of the great successes in the history of telecommunication – the communication satellite – was conceived by a man best known for his science fiction writings: Arthur C Clarke.

The term "cyberspace" is becoming the preferred term for referring to the global network of computers that connects millions of users, machines and information bits. One of the most popular services offered is electronic mail which allows people to send messages to each other. Arguably, fax machines and voice mail systems already provide adequate messaging facilities. One of the challenges of this issue is to convey how and why a number of seemingly trivial services on computer networks have become a powerful medium referenced by a spatial metaphor – cyberspace. Technology alone does not provide the explanation.

While the personal computer and video games entered the scope of public interest in the 80s, computer networks silently crept through the wires into increasingly computerised academic environments. The situation is changing rapidly as the notion of cyberspace gets into the loop of mainstream mass media. Also, while the networks developed without the active participation of the telephone companies, telecoms are now starting to offer access to cyberspace.

The increased attention will bring new groups of immigrants to the net. So far, the inhabitants have been an international, but homogeneous group of computer-literate academics. The merchants will enter with the hope of peddling information, while the Nintendo generation bring their familiarity with modern technology. These new groups, along with advances in computer and telecom technology, will change the face and content of cyberspace in years to come.

Also, new and innovative user interface technologies allure users and lower the threshold of entering cyberspace. Computers are increasingly capable of handling and combining media types such as text, graphics, images, audio and video – so-called multimedia, and this will give us better tools for navigating information.

The goal of this issue of Telektronikk is to present current research issues in distributed multimedia applications, and the role this technology may play in our lives – if we allow it to.

Windows into Cyberspace

BY HÅKON W LIE

654:681.3

This issue of Telektronikk will describe a world into which many people enter, but few escape. The lion's cave of the 1990s is filled with people like yourself – very much alive and kicking, but still entangled in an addictive web of technological and social relationships.

Reading this journal is probably not addictive in itself. In order to get hooked you need access to a computer which will be your window into cyberspace. Chances are that you already have a computer, and perhaps it is even "on the net" as cyberspace inhabitants call machines they can reach. If you are reading this on paper, the best thing to do is to throw away the pulp and start exploring cyberspace through your own window. In there somewhere you will find an electronic version of this document (for hints on where to find it, see the text box *The electronic Telektronikk*).

Whether you are reading it on paper or not, this introduction will present some fundamental concepts used in the articles that follow. Also, it tries to point at some of the current issues in the world of networked computers. These issues are not within a clearly defined field, and "Cyberspace" is one of the few terms that are general enough to include most of them. We are currently seeing several fields converge in a confusing array of mergers, foundations and strategic alliances. Negroponte's circles from 1978 – in the figure he predicts the coming together of three industries: broadcast, publishing and computers – are coming closer (figure 1a). In addition, at least two more industries are joining the loop: telecommunications and video games (figure 1b).

The common denominator in these fields is information. Information is also the foundation of computer networks, and we start by looking at the vehicle of information distribution: the exchange format.

Information exchange formats

There are many ways to classify information; one well-known system is Dewey's which is used to categorise information into thematic hierarchies. Computers are not good at dealing with thematic issues; from the computer's perspective, the difference between a textual description and a picture (e.g. a picture of a chair and a text describing the chair) is much more significant than the difference between two pictures, no matter how different they are. Therefore, we start by classifying information into *monomedia:* text, graphics, images, audio, and video. Among these, text is arguably the easiest to handle. Let us take a closer look at text.

Computers work with numbers. They are in fact very good at doing simple things with numbers, like adding two of them together, or remembering them. So, if we want a computer to store, process, transfer, or present information – there are some very good reasons for wanting this – we need to represent the information in terms of numbers.

The electronic Telektronikk

Describing state-of-the-art in electronic information distribution will not have much value without a practical implementation. Therefore, this issue is published in electronic form through the network as well as on paper. Since this journal, like most publications these days, utilise desktop publishing systems, the extra work of making an electronic version globally accessible is not significant, and the text versions of the articles will be available several weeks before the paper version is ready. Also, in addition to text and images, the electronic version will include audio and video, although at a limited scale.

You can access the electronic version through the *World Wide Web.* (There are references to WWW in papers by Solvoll et al., Dybvik and Maartmann-Moe.) The Universal Resource Locator (the electronic equivalent of ISBN) for this issue of Telektronikk is "http://www.nta.no/telektronikk/4.93", and if you do not know how to apply this knowledge, your system administrator probably knows. If not, feel free to contact the guest editor.

Reading the electronic version has some benefits: you can use your favourite font, search for keywords of interest, or perhaps tell your computer to read the text out loud. Also, paper has its advantages. It is portable, light, and offers a higher resolution than you computer screen. We are still in the stone age of electronic publishing, and what you are seeing on your screen is the equivalent of rock carvings. But increasingly popular rock carvings.

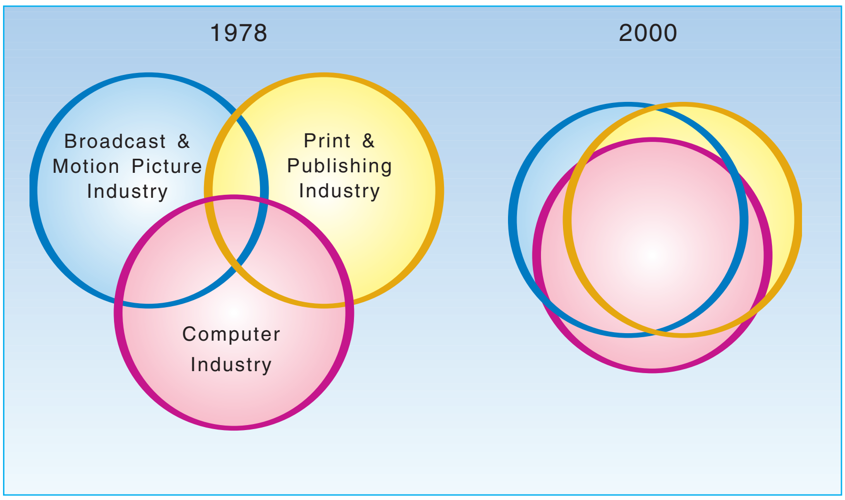

Figure 1 a We now find ourselves closer to 2000 than 1978, and Negroponte's figure has so far proved right

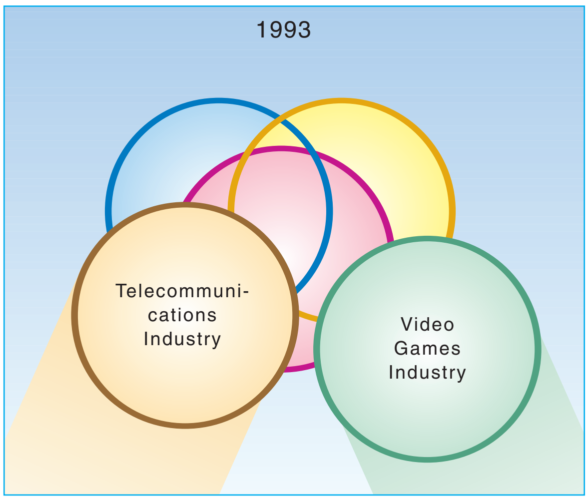

Figure 1 b Two more industries are eagerly joining in

Let us take a simple example: we want the computer to remember the first sentence of this paragraph so that we can retrieve it later. The first letter is ‘L’, so we will have to assign a number to represent the letter ‘L’. Since we already know the Latin alphabet we start counting and pick the number 12 to represent ‘L’. Next letter is ‘e’. Again counting – ‘e’ must be represented by the number 5. Wait! 5 represents ‘E’, not ‘e’. We will have to pick a new number for ‘e’ – how about 101? Doesn’t seem logical? It really is not, but at one point in history, the number 101 was chosen to represent ‘e’ in a table known as ASCII (see the text box *An historical anchor: ASCII*).

The ASCII table has become an internationally accepted way of coding text. In addition to ‘e’ and ‘E’, all common characters can be found in there. It contains 128 entries which at first glance seems to be sufficient for representing all texts. But, if that was the case, your favourite word processor should have no problems exchanging data files with your neighbour’s since they both could use the ASCII table. And, in fact, most word processors know ASCII and *can* use ASCII when saving or retrieving documents. But, when doing so, information is lost. When your document comes up on your neighbour’s screen, chances are that your favourite font has been replaced with gothic, and your carefully prepared layout is lost. Also, your native language’s special characters – if they were present – surely have degenerated into some other special interest language’s characters. There have been – and still are – attempts to create a common format for text, but no format has yet become universally accepted.

Computers have been processing text for some decades, but text is still – as we have seen – problematic as a data type. In the last decade, computers have evolved into machines that also claim the ability to process and present other data types such as audio, video and graphics. *Multimedia* is here – at least it will show up tomorrow if we can find the right distribution format (for more on Multimedia, see separate text box).

The introduction of more data types further complicates the task of designing and agreeing upon formats for storage and distribution. Isolated, they each exhibit some of the same problems as text; what properties do we want to store, to what level of detail, and how do we encode these properties? Together, they pose new problems when incorporated into a compound format to handle multimedia publishing. How do the various data segments relate to each other in time, space and content; how should these relationships be encoded; and to what level of detail? Also, it is debatable whether layout information should be part of the document – perhaps the reader

Multimedia

Being somewhere between a buzzword and a standard computer feature, “multimedia” has escaped all attempts of definition. The label is attached to any software or hardware trying to achieve symbiotic relationships between two or more of the following monomedia: text, graphics, images, audio and video. In the context of computers, this symbiosis takes place on a computer screen, preferably with the user being able to interact at will. In many current systems, the symbiosis never occurs, and “interactivity” turns into an endless chain of mouse clicks.

Only recently have computers reached a point where they can claim to handle multimedia. The presentation of audio and video is demanding on the part of the computer for several reasons. First, the amount of memory required to represent an utterance as a digital audio recording is thousands of times larger than the textual representation of the utterance. Adding video further increases demand for computer resources. Secondly, both audio and video are “continuous” media types, i.e. their playback requires a constant data stream – something a computer often finds hard because of other duties.

One challenging area of multimedia is the *transcoding* from one medium to another. E.g., a speech synthesizer attempts to transcode from ASCII to human speech, and speech recognition systems go the other way.[1] Transcoding is hard to get right, and some of the theoretically possible conversions are yet far from being realised – e.g. transcoding from a still image to text, or from text to video.

[1] *Transcoding from speech to images is the topic of Lie et al. on page 72.*

An historical anchor: ASCII

The American Standard Code for Information Interchange (ASCII) was defined in 1963 by the American Standards Association. In its original form, it defined 128 characters, including the English alphabet. Later versions have 256 entries to make room for other Latin-derived alphabets as well. The table will be a common reference in the next three decades as well. Cut it out and keep it handy.

0 NUL	1 SOH	2 STX	3 ETX	4 EOT	5 ENQ	6 ACK	7 BEL
8 BS	9 HT	10 NL	11 VT	12 NP	13 CR	14 SO	15 S
16 DLE	17 DC1	18 DC2	19 DC3	20 DC4	21 NAK	22 SYN	23 ETB
24 CAN	25 EM	26 SUB	27 ESC	28 FS	29 GS	30 RS	31 US
32 SP	33 !	34 "	35 #	36 $	37 %	38 &	39 '
40 (	41)	42 *	43 +	44 ,	45 -	46 .	47 /
48 0	49 1	50 2	51 3	52 4	53 5	54 6	55 7
56 8	57 9	58 :	59 ;	60 <	61 =	62 >	63 ?
64 @	65 A	66 B	67 C	68 D	69 E	70 F	71 G
72 H	73 I	74 J	75 K	76 L	77 M	78 N	79 O
80 P	81 Q	82 R	83 S	84 T	85 U	86 V	87 W
88 X	89 Y	90 Z	91 [	92 \	93]	94 ^	95 _
96 ‘	97 a	98 b	99 c	100 d	101 e	102 f	103 g
104 h	105 i	106 j	107 k	108 l	109 m	110 n	111 o
112 p	113 q	114 r	115 s	116 t	117 u	118 v	119 w
120 x	121 y	122 z	123 {	124 |	125 }	126 ~	127 DEL

should be able to set layout preferences? There exists a tension between the interests of the author and the interests of the readers, and the document format is where the battle will take place.

After having gone through some of the problems of defining a format for multimedia messages, one may welcome the fact that other approaches exist. The fax machine is based on one of them; instead of encoding a document as individual characters, words, sentences, and paragraphs, the fax machine treats each page of the document as a picture. This has several important implications:

First, the fax machine is able to convey anything visible on a sheet of paper, whether it be text, figures or photographs.

Secondly, the computer – for the moment camouflaged as a fax machine – loses the ability to do neat things with text that computers are good at (e.g. searching) since it has no notion of text whatsoever. All it sees is images, and computers cannot perform operations on the content of images.[2] If you want the computer to process the textual content of a fax message, you most likely have to retype it yourself.

[2] *For an innovative approach to help computers handle the semantics of video, see Marc Davis' article on page 59.*

Thirdly, due to the strong binding to paper, fax machines will not be able to convey audio or video.

Also, the fax machine has probably wasted both time and paper before it reaches the recipient. A typical path for a faxed document is described in figure 2.

Although a highly successful telecom product in terms of use, the fax machine is a horror example of the importance of taking the changing topology of telephone networks into account when defining information exchange formats; computers with memory and processing capabilities are increasingly terminating our networks, and we should no longer design our protocols for the lowest common denominator – of which the fax machine is a prime example.

The content of Cyberspace

Creating formats for computers to exchange information is an interesting exercise with some thought-provoking implications, but for most people the applications that take advantage of these formats are more relevant. So, let us start at the other end by looking at some applications of distributed multimedia.

Given the freedom of a fresh start, what applications, or more to the point – what data do we ideally want to be presented to, and in what form? The answers to these questions will vary from person to person, and from time to time. People have different backgrounds, interests, skills, handicaps, and preferences. Some of these variables change slowly – learning a new language takes years, while others change frequently. When starting your car, you acquire a new handicap with regard to information systems; suddenly you lose your eyesight. Technology has the potential of compensating for handicaps (your computer can read to you while you drive), and adjust for personal preferences (by e.g. helping you find information items you are seeking).

One metaphor, into which several of the applications discussed in this issue can be put, is the "personalised newspaper". The newspaper as we know it on paper is a universally accepted product that over the last centuries have developed into a highly advanced presentation medium. The front page gives readers an instant overview of the most important stories, and the headlines make it possible to scan large amounts of information quickly (see figure 3). Simply by switching from scanning to reading, the user is able to change modality from overview to detail. The front page is your menu in which the selections are available immediately.

However, paperbased newspapers have deficiencies that are much due to the distribution technology currently utilized. All copies of a daily edition contain the same information which the editors have selected based on the perceived interests of the readers. If we replace the printing press, trucks and paper boys with electronic distribution, we suddenly achieve new degrees of freedom:

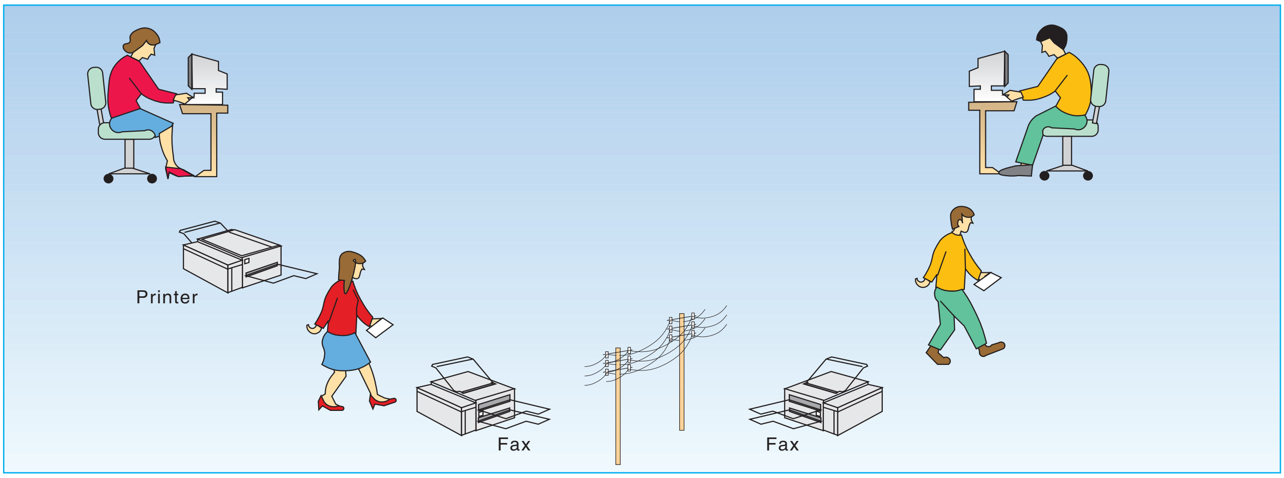

Figure 2 A typical path for information that is faxed. Most likely, the information originated in a computer. As the message moves toward the recipient, the quality of presentation (e.g. legibility) drops and the logical structure of the document is lost


Arbeiderbladet
LØRDAG SØNDAG
– RUNE ER FARLIG FOR GRO
Hun beste ÆRLIGHETS-TESTEN
LUCY CAROLINE i nærbilde
BLODMAT, HOMOSEX
KONGE-FEST!
FOTBALL-FEST!

Figure 3 You can read it even if you do not know the language

Figure 4 Screen size of choice?

Digital vs. analogue

One fundamental feature of computers is that they represent data in digital form, i.e. using discrete numbers instead of continuous values. For some data types this makes sense. A character is either an ‘A’ or a ‘B’, it is not somewhere in between – characters are discrete. However, not all data we surround ourselves with have this property. E.g., the colour of the sky is not blue or red, it is more likely to have elements of both and change continuously.

Audio is another data type that from nature comes as continuous signal, i.e. variations in the air pressure. An audio signal can be represented as a function of time (figure 5a).

If the audio signal is to be transferred through a digital telephone system or stored in a computer, it needs to be digitised. In the digitisation process, the continuous changes in the air pressure are *sampled* at a certain frequency, and the sampled values are rounded off to the closest discrete value (figure 5b).

Images are also represented digitally through a sampling process. A scanner looks upon the image as a two-dimensional grid, and measures the chrominance and luminance of each pixel.

The move from analogue to digital systems is a fundamental change that is taking place in all media. The digital CD replaced the analogue LP in just 10 years, and the next generation radio and TV broadcasting systems will be digital. Telephone systems are digital, except for the last kilometer into our homes – and that is about to change as well.

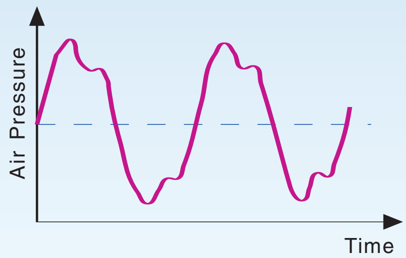

Figure 5a

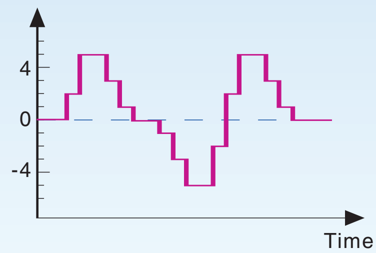

Figure 5b

Presentation: Your front page can look different from mine; your favourite font will shine to you on your screen size of choice (figure 4), or come out of your domestic printer when your alarm wakes you up in the morning.

Content: The computer will present articles of interest by searching wire services on your behalf. Also, messages addressed to you personally (e.g. electronic mail) will appear in your newspaper as well as discussions on electronic bulletin boards that you take interest in.

Functionality: If your newspaper appears on a screen, you can take advantage of continuous updates of articles. Video and audio will enhance the presentation, and the ads will talk to you.

If we exploit the freedoms offered by the technology we will end up with a medium quite distinct from current newspapers. The new medium will have its own characteristics that surely will be subject to debate in years to come.

Another angle from which we can approach the same idea is labelled *interactive TV*. TV, in its current linear form offers no user participation, except for switching channels. Some TV broadcasters – eager to extend their domain and fearful of a future without them – have started well-publicised experiments with interactive TV. In Europe, TV stations enclose pages of text that carry news, advertisements and programming information in the TV signal. The user selects information from menus through the remote control. If one includes more memory and processing capabilities into TV sets, one can easily imaging video being selected interactively in a similar fashion. However, true interactive TV will first become a reality when the feedback loop closes and the user gets a chance to respond to and request information. We will come to that shortly.

Whatever angle one takes, huge amounts of information will be available, and computers will assist selection and presentation.

Telecommunications

Today’s telecommunication systems use a mixture of digital and analogue transmission (for a description of the difference between analogue and digital, see the text box *Digital vs. analogue*) When you pick up the handset, chances are that you are connected to your exchange with a pair of copper cables. Most likely, these cables transfer your voice as an analogue signal from your telephone to the telephone company's exchange. In the exchange, your voice is transferred into the digital domain where it stays until it reaches the exchange of your interlocutor. For voice converted, which is analogue by nature, this works fine (see figure 6a). The short distance over which the signal is analogue does not degrade it noticeably.

For computers, however, which start out with a digital signal, the number of conversions double (see figure). Making audible signals out of ones an zeros – which is exactly what a modem does to an outgoing signal – is not a very efficient method of transmitting data over copper cables. A typical modem is able to send 9600 bits per second using an analogue phone line – only a fraction of the potential. See figure 6b.

The logical solution to this problem is to complete the digitisation process, i.e. transmit data digitally all the way to your house or desktop. There, anything that naturally comes in the analogue domain (like your voice) will be converted, and anything that is discrete by nature (e.g. text) will flow more gracefully. The telephone companies have labelled this step ISDN (Integrated Services Digital Network), and they have been planning it for decades. See figure 6c.

ISDN will run over the copper cables that already connect households to the telephone network. At 128 kbits/s, ISDN offers a performance increase of a magnitude compared to current modems.

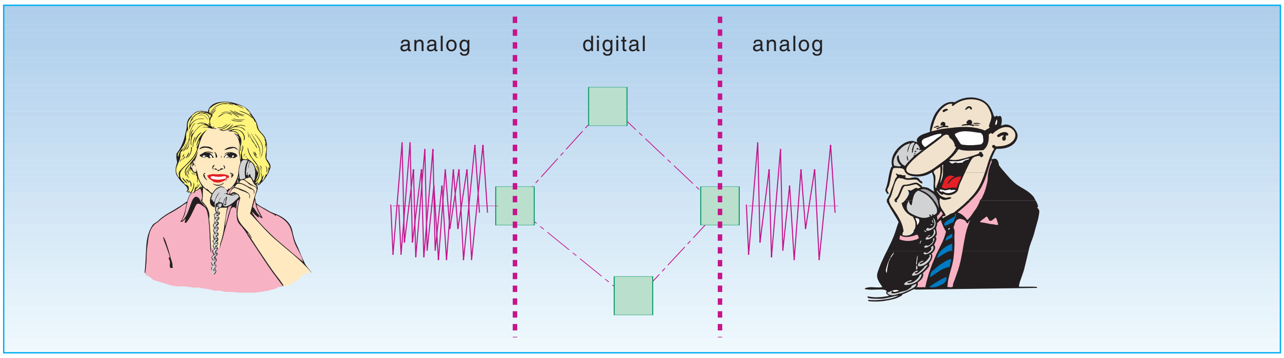

Figure 6a Two conversions between analogue and digital signals are required to transmit voice through digital telephone systems

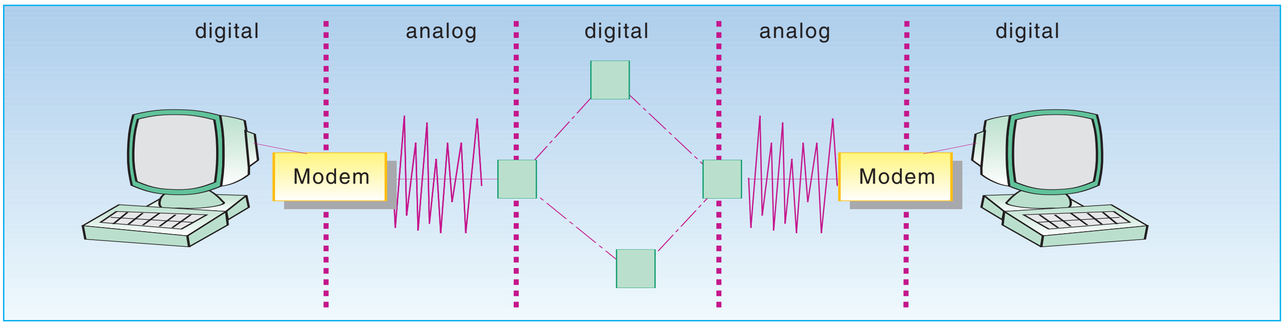

Figure 6b Computers prefer to communicate without any digital/analogue conversions, but current phone systems require four such conversions

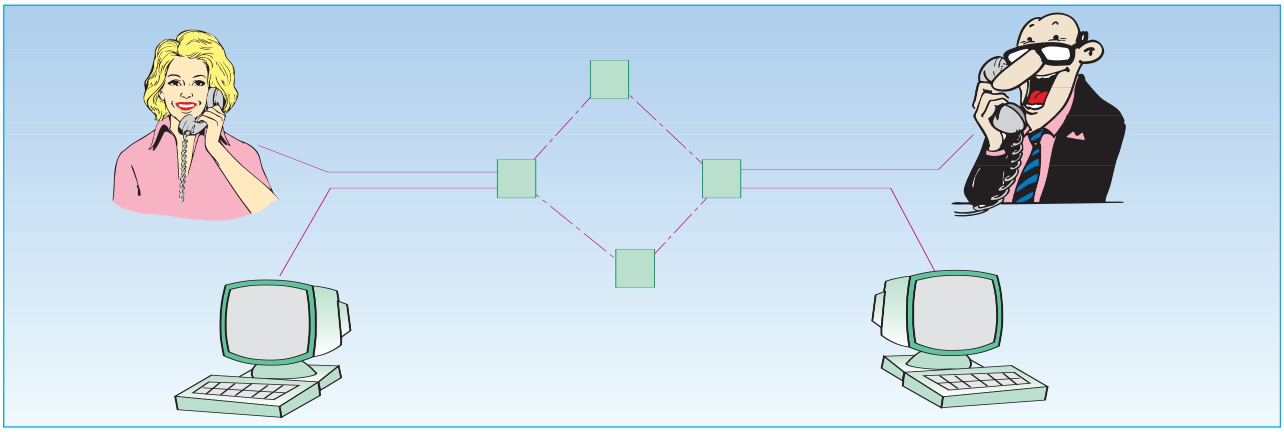

Figure 6c ISDN offers all-digital transmission for voice and data

ADSL – a concept for high-speed transmission on copper lines

By Knut C Aas

An emerging transmission technology called Asymmetric Digital Subscriber Line, ADSL for short, will in a few years enable transmission of large amounts of digital data over the telephone line into individual residences. This technology promises to make multimedia services such as video-on-demand and home-shopping accessible on a large scale.

Not too many years ago, it was envisioned that most homes in the near future would be connected to high-speed transmission lines making interactive multimedia services available to the general public. Electronic libraries containing video, audio and text could be accessed from the TV-set at the touch of a button. Fibre-optic lines were thought to be the means by which these services were to be delivered into each home. In the meantime, telecommunications companies have become more realistic. Though fibre has become the preferred medium for transmission between local exchanges, the final few kilometres between exchanges and residences consist of old-fashioned twisted-pair copper lines, which lack the large bandwidth of fibre-based lines that makes high-rate transmission simple. The cost of replacing these transmission lines on a large scale runs into billions, placing such investments far into the next century. Moreover, there is as yet no demand for broadband services existing today only on the drawing board. It has become evident that a transition to fibre will have to be gradual and be supported by an increasing demand for such services. It may appear that multimedia home-access has been relegated to the distant future.

But now prospects are looking up once again. In 1989 Bellcore introduced a concept that may put the information highway within the reach of this decade, at reasonable costs to telecommunications companies and consumers alike. The secret lies in taking advantage of digital transmission and compression techniques using the existing copper-based infrastructure to deliver digitised information at high rates. A key idea is that the envisioned services require high-rate transmission of video and audio in only one direction: from the exchange to the subscriber. Upstream transmission is required only for simple control signals initiated by the user, such as for selecting programming and services from a menu, which can take place at much lower rates. This consideration together with advances in digital signal processing and VLSI technology, have put transmission via copper lines within the realm of the possible, giving rise to the Asymmetric Digital Subscriber Line (ADSL).

Copper lines are subject to several impairments. Signals propagating on such a medium are attenuated by an amount that increases with the length of the line. This limits the distance a signal can travel without being regenerated, which in any case would not be economically feasible for large-scale deployment. As high frequencies of a signal are attenuated more than low frequencies, the effective transmission bandwidth is limited to about 1 MHz, only a fraction of the bandwidth available on fibre. Moreover, the transmission loss is frequency-dependent and not easily taken into account even at lower frequencies. Performance is also adversely affected by traffic on adjacent copper lines in the same cable interfering with the transmitted signal; an impairment known as crosstalk. Such distortion cannot simply be eliminated by increased transmission power, as the interference would grow in proportion. Occasional impulse noise generated from external electronic appliances and AM radio broadcasts further degrade transmission quality. It is in such a sharply band limited, distorted and noisy environment that high-rate signal transmission has to take place. Needless to say, this places high demands on the new technology.

A proposed standard for ADSL splits the available transmission bandwidth into three parts, illustrated in figure a. The low-frequency end will as now be reserved for ordinary analogue telephone service, occupying the lower 4 kHz of the spectrum. Alternatively, a slightly larger piece of the spectrum may be used for ISDN basic rate access. The main bulk of the bandwidth in the range from

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Also, this bandwidth can be split into several chunks so that you can continue talking while the computer juggles data on your behalf.

128 kbit/s is good news if you are used to current modem technology, but you still need more than 11 hours to transfer the content of a full CD-ROM.[3] Often you do not care since you have no need for 600 Mb of archived weather information when all you want to know is if you should bring your umbrella – and that is exactly one bit of information. But there are times when nothing but bandwidth will suffice.

It has long been assumed that broadband services require the introduction of fibre to the home or desktop. This axiom is now being questioned by a copper renaissance movement. One technique that has gained a lot of attention lately is ADSL (Asynchronous Digital Subscriber Line), which will offer up to 6 Mbit/s into your home over existing wires (see the text box *ADSL: a concept for high-speed transmission on copper lines* by Knut C Aas for a description of how normal phone lines can achieve this). Going the other way – from your home to the exchange – the numbers are not that impressive, but we all consume more information than we produce.

The next step on the scale of performance is ATM (Asynchronous Transfer Mode) which will start at 155 Mbits/s – enough to transmit several channels of high-quality video and audio. ATM is a rare example of fruitful co-operation between telecom and computer vendors, and it will be used to connect exchanges as well as local area networks. Do not expect this service to be offered into your home yet.

While striving for more bandwidth, one should also try to exploit what is already available. A number of interesting ser-

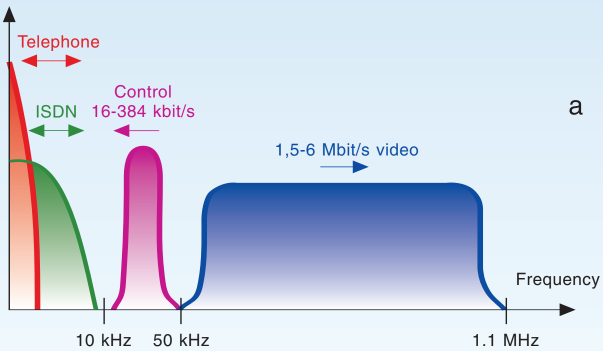
[3] *Maartman-Moe compares CD-ROM with the offerings of telecoms in his article on page 27.*

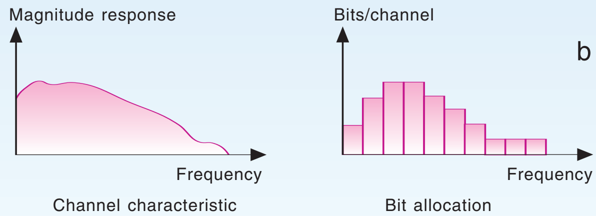
50 kHz to about 1 MHz is reserved for digital transmission of data in the downstream direction, i.e. from the exchange to the subscriber. The upstream control channel occupies the 40 kHz band in between, a figure which includes ample separation between the three bands. The signals in each channel can be extracted with an appropriate band-pass filter.

To deal with the frequency dependent loss and noise in a typical copper line, the downstream channel will likely employ a modulation technique known as discrete multitone (DMT). This technique divides the available bandwidth into 256 sub-channels of width 4 kHz each, and allocates transmission power to the individual channels depending on the noise power and transmission loss in each band. Each channel carries multilevel pulses that can represent up to 11 bits of data, while the poorer sub-channels carry fewer bits and can even be shut down entirely (figure b). The modulators can be implemented digitally in software or in digital logic, keeping production costs low. DMT has been used successfully in commercial high-rate telephone-voice-channel modems. To deal with occasional bursts of impulse noise, the digital signals can be encoded with error-correcting codes similar to those employed on compact disks that will enable transmission at bit error rates of 10–7 bits/s or better.

A commercially successful implementation of ADSL places minimum requirements on transmission capacity and penetration. While most customers lie within 3.5 km of an exchange, a small percentage may require transmission over distances of up to 6 km. Currently, transmission rates of 1.5 to 6 Mbit/s are being discussed for service over distances in this range. Advances in digitising and compressing video information make it possible to supply full-motion-video of acceptable quality at rates down to 1.5 Mbit/s. For instance, video encoded at 2 Mbit/s according to the MPEG2 standard compares favourably to traditional VHS recordings. Digital subscriber lines operating at this rate will be able to supply multimedia services to nearly all households in a region. Transmission rates of 6 Mbit/s over shorter distances will allow several channels to be viewed simultaneously at a single subscriber location. The upstream channel can be configured for transmission of up to 384 kbit/s. A few customers living in industrial areas with severe electrical interference may not be able to receive these services with the proposed design specifications.

For video-on-demand to be a success, the price for consumers must be competitive with video-rental, satellite, and cable-TV services. While the technology is still being developed, it seems likely that mass-produced ADSL transmitters and receivers will be sufficiently inexpensive for this requirement to be met. In that case, multimedia services may not be very far away. ADSL would allow for a gradual build-up of demand for more exotic broadband services. Ultimately, it may prove to be the means by which a transition to fibre in the subscriber loop is made possible.





vices can be offered through a standard ISDN subscription, and increased bandwidth will not always improve the service. Rather, bandwidth limitations will force us to think more intelligently about the data we are transmitting (see the text box *Data compression* for more on this).

Navigating Cyberspace

The flow of information through computer networks is in its infancy, but we are already far beyond the point where any human being can claim to have the overview of what resources are available. In order to lower the threshold for accessing information on the net, we need better tools for navigating cyberspace. The interface between humans and computers is by many seen as the bottleneck for taking advantage of modern technology, but the increased functionality of multimedia machines may help us widen the bandwidth of this interface. *Virtual reality* (VR) is one example of a technology that may help data navigation. Without knowing how to type, users are immersed in synthetically generated worlds where navigation is based on body movements. Head-mounted displays, headphones and motion sensors come closer to the user than traditional computers. Whether it will open new worlds or distort existing ones, virtual reality machines are here and the network will connect them.[4] See figure 7.

Hypertext is another alluring technology that will influence the way we interact with computers. On paper, footnotes, references, and boxes break up the linear structure of text, and the table of contents provide pointers to information. In electronic documents, all these features can

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[4] *Loeffler (page 83) and Ødegård (page 76) discuss distributed VR in their articles.*

[5] *Practical and theoretical approaches to hypertext are described by Liestøl (page 31) and Rasmussen (page 37).*

Data compression

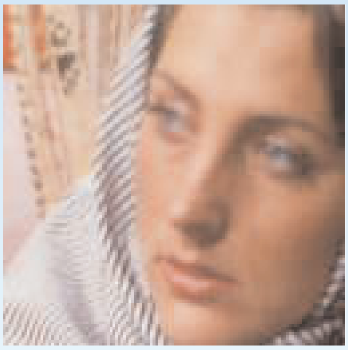
Together with increased performance in computer systems and digital networks, improved data compression techniques are requisites of modern media technology. Data compression is the science of removing redundant information from a message to minimise the number of bits that need to be stored on a disk or transferred through a network. In a world with unlimited and free bandwidth, data compression would not make sense. In a world with stringent physical and economical constraints – which happens to be the case where we live – data compression makes a lot of sense.

One early example of a data compression scheme is the digital communication system named after its developer, Samuel Morse. By assigning shorter representations (or *keys*) to the most frequently used characters (e.g. 'e'), telegraphers could send messages faster than if all characters were represented by same-length keys (which is the case in ASCII). While the basic idea has continued to be the foundation for many compression schemes, the search for optimal key assignment algorithms has improved compression ratios. A text file coded in ASCII will typically shrink to half the size being compressed with modern algorithms.

One vital feature of compression schemes for text is that they are *non-lossy*, i.e. no information is lost in the compression-decompression process. When compressing images, the virtue of non-lossiness is not that important. Certain characteristics of the human visual system can be exploited to achieve higher compression ratios. E.g., our eyes are less sensitive to the colour blue than they are to green. We can take advantage of this when compressing a colour image by throwing away some of the blue information that our eyes probably would not detect.

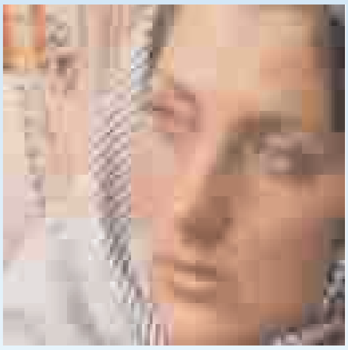
Recently, some interesting lossy compression schemes have been introduced:

- JPEG: Still image compression scheme where detail can be traded for higher compression ratios. See images below.
- MPEG: "Moving Pictures" compression. Based on the same principles as JPEG, but also takes advantage of similarities in succeeding pictures.
- Philips and Sony have introduced audio compression schemes for use in DCC (Digital Compact Cassette) and MD (Mini Disc) respectively.



The original 128 x 128 image contains 49152 bytes of information.

Moderately compressed using JPEG, the image above contains 3586 bytes of information (compression ratio 1:14).



The image now contains only 1498 bytes of information, and compression artefacts can clearly be seen (compression ratio 1:32).

be implemented through hyperlinks.[5] By selecting a highlighted text or picture, the computer will take you to the other end of the link. While hypertext documents of the 1980s referenced themselves in closed loops of canned information, some modern systems support network-transparent links.

The inhabitants of Cyberspace

Technology is the foundation of cyberspace. But, it is not only a network of computers – it is also a network of people. As will be stated more than once in this issue, the net is growing quickly. However, merely talking about growth hides some of the conflicts that will arise in the years to come. New groups of people are flocking to the net – some come for adventure, some to make money, and some to escape their past. This is not merely growth, it is immigration.

Hackademics

Up to now, people on the net have been a relatively homogeneous group of academics with an enthusiasm for computers – "hackademics" (see the text box *Hackers* for an explanation of the first part of the term). In the 80s they found how useful a personal computer can be for word processing. In the 90s, the same people

Figure 7a Lost in Cyberspace?

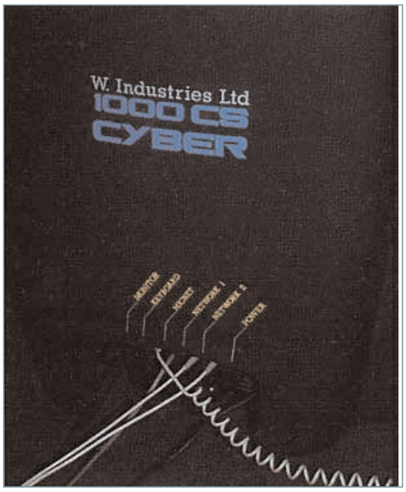


Figure 7b The back side of a VR gaming machine: network connections

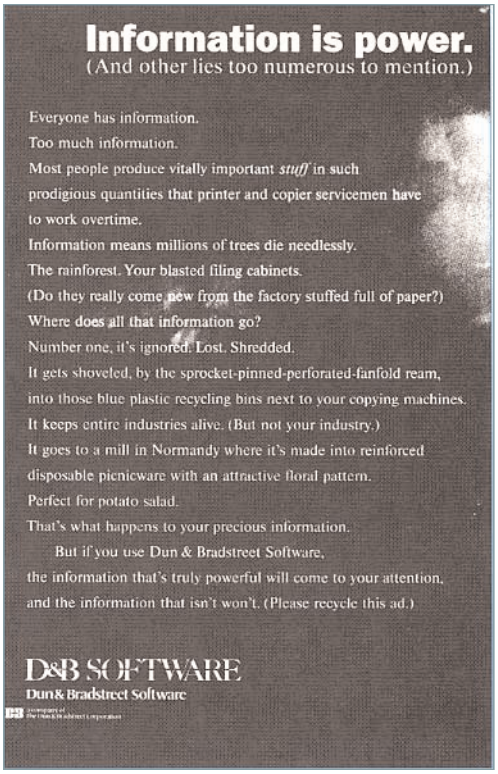


Figure 8 Information overflow

Hackers

In the 60s, computer subcultures appeared in American university environments where the inaugurated were called hackers. The true hackers had, and still have, high ethical values:

- Access to computers should be unlimited and total
- All information should be free
- Mistrust authority – promote decentralisation
- Hackers should be judged by their hacking, not bogus criteria such as degrees, age, race or position
- You can create art and beauty on a computer
- Computers can change your life to the better.

This ethic is heavily influenced by prevailing academic views on information, and the net was conceived in the intersection between these cultures.

Later, the term "hacking" has been abused to label illegal and malicious intrusions into computer and phone systems. A better word for this is "cracking".

found how much more interesting computers become when linked in global networks.

To hackademics, information is sacred. Life is used to study information, turn it into knowledge – and convert it back into information by "publishing". For example, one writes a scientific article, submits it to a scientific journal and hopes to spread the word in scientific circles. There is seldom any monetary compensation for making information available, academic glamour is often the motivation. It is no coincidence that this group has taken the net into active use; here they find a medium through which they freely can access information and communicate with peers.

Among the new groups that will appear on the net in the years to come are the information merchants and the Nintendo generation.

Merchants

On the net, information has mostly been available free of charge up to now. The merchants come to peddle their information, which means that information comes at a price. Still, many argues, in order to increase the diversity and quality of information, commercial information vendors should be allowed access. Stewart Brand describes the tension that will appear:

> *"Information wants to be free because it has become so cheap to distribute, copy, and recombine – too cheap to meter. It wants to be expensive because it can be immeasurably valuable to the recipient. That tension will not go away."* (Stewart Brand)

The merchants are likely to be organisations that already own and distribute information. For them, the computer is just another medium, but one of increasing importance. They are likely to argue for using the same conventions and statues as cover paper-based publishing.

> *"We have become an information society. Numerous people depend on information stored in computers for their economic or physical well-being; many make their living by working with information rather than with tangible goods. In such a society there are economic and social reasons for not making all information freely accessible. (...) Over many centuries, people have come to regard certain information as an ownable asset that can be valued. (...) The owners of such information depend financially on their ability to control access to their information."*
>
> (Dorothy Denning)

However, many argue that the characteristics of each medium also should influence the way we handle it:

"The recognition of copyright and the paying of royalties emerged with the printing press. With the arrival of electronic reproduction, those became unworkable. Electronic reproduction is analogous not so much to the print shop of the eighteenth century as to word-of-mouth communication, to which copyright was never applied."
(Ithiel de Soola Pool)

Moving further away from the traditional view of the information merchants:

"There's something wrong with the Information Society. There's something wrong with the idea that 'information' is a commodity like a desk or a chair. (...) There's something unprecedented and sinister in the process of creeping commodification of data and knowledge. (...) I don't think democracy will thrive in a milieu where vast empires of data are encrypted, restricted, proprietary, confidential, top secret and sensitive. I fear for the stability of a society that builds sand castles out of databits and tries to stop a real-world tide with royal commands."

These views come from Bruce Sterling, an author who makes a living selling information.

The Nintendo generation

In a message posted on the net in 1991, Brewster Kahle describes how video games have captured the minds of a generation:

"Currently Nintendo games, are attached to televisions in 25 % of American homes. They are the home computer market. The "software" is proprietary or licensed game cards that give the game its characters, "plot", and sound. Simple controls are used to manipulate the characters in plots that are 2 1/2-dimensional adventure games. These games are attracting children by the millions. Some parents have said, Nintendo is distracting children from watching television. It is amazing to think that low-resolution, low-variation games can compete successfully with crafted, funny, TV programs, but they are. Why? Because children seem to want to interact, have an effect, participate, develop, and prove themselves."

He goes on describing the potential of communication embedded in Nintendo games:

"Turn over a Nintendo game and you will see a punch-out for a telephone hookup. Call their 800 number (also on the game) and some nice operator will tell you it is for future enhancement for multiuser games and the like. Nintendo has run an experiment in Japan with 30,000 families to test this type of system. They have started talks with phone companies in the US (AT&T most publicly), and have made a deal with Fidelity Investments already to distribute information in the United States. Convinced? Nintendo is not a standalone box."

Convinced? Video games will move into the networks and perhaps even become a respectable service.[6] Already, Americans spend more money on video games than they do going to the movies.

Figure 9 A favourite pastime that has named a generation

Postscript

When designing systems that have the potential of changing the way information is communicated in a society, one should realise the existence of some social responsibilities. The systems that are discussed in the following articles may change the way we work[7] and play, and a minimum of the resources should be available for everyone to use. This responsibility should be undertaken by all groups involved in shaping the future, from programmers and information vendors to bandwidth providers and government.[8]

Further reading

The articles that follow will further elaborate on topics discussed in this introduction. They are written by active researchers in the field, and provide reports from the trenches.

In addition to the articles, the following sources have been inspirational when writing this introduction, and they are hereby recommended:

Robert Metcalfe. Will networks be the bottleneck? *Eurographics 92,* State of the Art Reports, Cambridge, England, 1992.

All issues of the magazine *Wired.*

Stewart Brand. *The media lab – inventing the future at MIT.* New York, Viking Penguin, 1987

Whole Earth Review's special issue on Questioning technology, No. 71, winter 1991 (in it you will find Why multimedia publishing is a crock, by Tim Oren).

Steven Levy. *Hackers: heroes of the computer revolution.* Garden City, New York, Anchor Press/Doubleday, 1984.

Peter J Denning (ed.) *Computers under attack.* New York, ACM Press, 1990.

Ithiel de Soola Pool. *Technologies of freedom.* Cambridge, MA, Harvard University Press, 1983.

Time Magazine, September 27, 1993 (vol 142, no. 13), cover story: The attack of the video games.

New opportunities for publishers in the information services market. Commission of the European Communities, 1993.

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[6] *Unfortunately, we could not find any academic who was willing to jeopardise a career by treating this field seriously.*

[7] *Syvertsen and Schieflo (page 89) and Sørgård (page 99) discuss the options and pitfalls of electronic communication systems in the workplace.*

[8] *Hakken (page 106) outlines views on politics and information infrastructure.*

Altruism and benefit in Cyberspace

BY BØRRE LUDVIGSEN

654.1:681.3

Knowledge is the only instrument of production that is not subject to diminishing returns.

J M Clark,
Journal of Political Economy,
Oct. 1927

In times of great change

One of the major reasons for the acceptance of change is to meet and presumably resolve new challenges. In spite of apparently accelerating change, challenges to society both local and global appear to outstrip that justification of progress at an even greater rate.

As I write this on a fairly ordinary September evening, the past 2 hours have seen me send 13 scanned postcards from Lebanon to a colleague in Sweden, pick up some software in Oregon, "chat" on screen with a friend at Lillehammer, advise a student working on a project, carry on a discussion by email with a friend in England, send a fax to the US and read a few articles in my favourite electronic news group. All from the comfort of my home office, all from my personal workstation and all in real time at fairly satisfactory transfer rates. On the same screen, or one of the other screens of several personal computers in my home office, I can watch and digitise live television from a choice of more channels than I care to count. Running an experimental remote workplace for the Norwegian Telecom, I have, as the expression goes, the world at my fingertips. I can communicate with a substantial number of people all over the globe. A very important factor is that we communicate in many modes, with respect to time, place and action. We can relate as individuals and groups in both transmission and reception. Most important of all we can act, not only communicate. In other words, our communication can provoke actions influencing not only ourselves as participants, but others as observers, and consequently propagate both knowledge and action.

The project has allowed me to look into and experience permutations on ways in which information technology (IT) might develop. That development which is necessary to accommodate the degrees of knowledge augmentation necessary to meet the challenges that seem to overwhelm us. For it is not in specialised fields that there are particularly great needs for knowledge augmentation. Those classes of society and professions that already have access to the information they need are doing quite well. For the most successful, aptly exemplified by our own Middle East negotiators, the necessary information for problem solution is actively collected in the field as a matter of course. But those communities in this global society, which has increasingly come to rely on interacting information and information about interacting processes as guides for collective action, who do not have interactive access to information, are increasingly left behind as disadvantaged.

It is that majority of society on which we will have to rely in meeting and resolving those challenges that increasingly threaten the fabric of inter-communal survival. The informationally advantaged can only provide suggestions subject to confusing debate by their peers. The results of that debate have only in a few instances provided solutions that form the basis of guidance to communal solutions. More substantially, that debate, while being evidence of measured democracy, has also provided the basis for rejection of political and social stability, more often than not resulting in turmoil at worst and decadence at best.

A state without the means of some change is without the means of its conservation.

Edmund Burke
1729–1797

The development of public electronic information systems

This year sees the 70th anniversary of Norwegian broadcasting. As with many other broadcasting endeavours, it started as a mainly technological achievement. But even during the first broadcast, the aims of the effort was declared. It was clearly understood that it was necessary that the enterprise have a clear purpose and one that was understood to be reasonably altruistic. The opening broadcast stated quite clearly that public radio broadcasts in Norway would be run with the purpose of public information and enlightenment.

The development of electronic information systems for public use which started with the telegraph have been successively complemented by the teleprinter, telephone, radio broadcasting, telefax, television broadcasts and digital computer networks. Each system has its own very particular characteristics and implications for the way in which information is disseminated and used. The latest one is that which concerns us the most, as it is the least mature and represents the greatest potential in merging the characteristics and potential of all the previous combined.

Before we dismiss them as primarily corporate and technically removed from the

Figure 1 The users in our family network ludvigsen.dhhalden.no, a sub domain of the Internet. Stig and Antonia at the left have moved to Ghana , and Sebastian, seated has moved to Sandnes. But Eva (back centre), eval@ludvigsen.dhhalden.no, Børre (right), borrel@udvigsen.dhhalden.no and Linn Iren (on the screen), linnh@ifi.uio.no, remain avid users

public at large, it should be noted that both telegraph and teleprinter represent unique and far-reaching changes in the societies that took advantage of them. Both telegraph and teleprinter were essential to the industrialisation of western society. It is also interesting to note that the teleprinter, which was basic to the development of the financial supporting structure of western society through dissemination of stock market information, was the immediate precursor of the interactive computer network.

These electronic communication systems have two basic modes of operation that characterise their influence on society at large. While radio and television broadcasting is technically non-interactive and transmits one-to-many, the wire based telegraph, telex and telephone systems are essentially interactive, transmit and receive in one-to-one patterns. These very different modes of use determine strongly the way in which they are used and the way in which public authority view their usefulness. Tempting though it may be to follow the development of public IT along technological lines, it is the social relationship to the various technologies that set the conditions for the way in which they are used both by authority and public.

As recent events have illustrated beyond reasonable doubt, it is the measure of democracy that determines the relative success of societies whether they be rich or poor. And it is the measure of active citizen participation which determines the success of democracy. In his article The Economics of Life and Death (1), Amartya Sen argues convincingly that "It is significant that no democratic country with a relatively free press has ever experienced a major famine (although some have managed prevention more efficiently than others). This generalisation applies to poor democracies as well as rich ones." So what has been the role of IT in the success of democratic societies and what are the prerequisites for successful progress in that development?

Let us first look at the various ways in which public IT have been applied and used. The simplest IT-system, the telegraph, has virtually disappeared from public use. It is used only in the most difficult of radio conditions for point-to-point communications where its very concentrated bandwidth has the ability of penetrating noise that would otherwise obliterate comprehension of message. Similarly, the telephone is a fairly uninteresting form of public communication as it is essentially also limited to one-to-one communication and not very suitable for broadcasting. Although both the telephone and telegraph have been extremely successful as strategic implements in both personal lifesaving and national campaigns, it is probably the attitude to their position in relation to public awareness that is the true measure of their significance. It is noteworthy that in his biography of Kemal Ataturk, the "father" of modern Turkey, Lord Kinross often mentions the importance of the loyalty of the telegraph service as a weapon in the struggle against the allied victors of World War I in forging a nation from the remnants of the Ottoman empire (2). It might at first thought appear odd that the telegraph would survive a war situation. Much in the way it might appear curious that telephone is not the target of suppression by occupying forces at time of war.

Broadcast radio on the other hand is often the immediate target of suppression and control. The confiscation of radio sets during the early days of the German occupation of Norway during World War II is indicative of the attitude of public authority to important public IT systems. While telephone and telegraph is just as important as a source of surveillance as it is a means of communication, the geographical coverage and character of content in broadcast radio was considered too dangerous for it to remain freely available. The lengths to which various Eastern European nations have gone to jam western radio broadcast up until the end of the 1980s is adequate illustration of similar politics. What is so significant in the way radio is used?

At the height of its development as public communication system, broadcast radio was singularly well adapted as a means by which to disseminate the information that built the knowledge base that caused the tremendous social and political transformations during the first half of this century. It appears to have been particularly significant in the building of democratic forms of government. Norwegian radio had the declared aim at its launching to be a source of information to the public. During the pre-war years and during the period of national reconstruction after the second world war, radio was actively used by the

Figure 2 Gathering round a radio illegally withheld from confiscation to listen to the news from London during the German occupation of Norway. "The news from London gave hope and glimmers of light in a time of darkness", contributed by Kjell Strande, Molde (9)

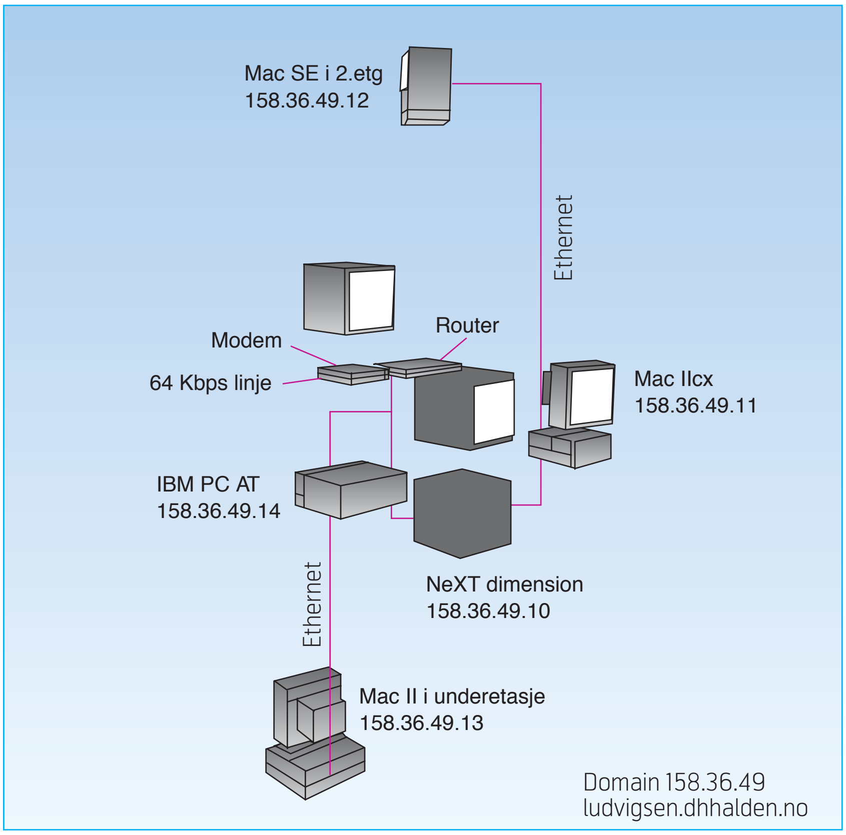

Figure 3 Our domestic digital network with floors, walls and roof removed. ludvigsen.dhhalden.no is wired into the Internet

Families would gather round the radio to concentrate on the message emanating from Oslo. Lectures of up to an hour and twenty minutes without breaks might be considered ridiculous in countries where the nature of broadcast radio was of a more entertaining nature. In Norway, however, the 1950s were years of relatively high deprivation. The radio provided significant information both with respect to material well-being such as preventive health programs, the efforts against tooth decay and regular exercise. Radio was in a curious way interactive. Not in a technical way, but in the way the information content it presented was utilised. Not only would families and extended groups of listeners gather round the radio and discuss what they had heard immediately after the program, the information sent would be debated in the workplace. Discussion groups, especially those instigated by labour unions, were both popular and important during those years.

It may quite successfully be argued that workplace discussions were as important in the destruction of the workplace itself as they were in its building. There can, however, be no doubt that this activity was quite earnestly directed at making social conditions better, both at work and in the home. Even though newspapers also were sober sources of news and debate, broadcast radio was a source of information that commanded the attention of the population at large during the extensive period that someone has termed internationally as the "golden years between V-J day and OPEC". Even during the early years of television, broadcast radio commanded significant popular attention in the population. There was a heightened sense that while television represented entertainment, radio was responsible for impartial information and debate. I personally remember quite vividly listening to radio lectures and debates during the late 60s and some time into the 70s.

With the advent and dominance of television, the character of popular information through IT systems changed significantly. This article will not go into the debate on the degenerative social effects of television, but rather touch on its position in the gradual development of popular IT communication systems. For various reasons, primarily political, but also economic – the informational quality of television in this country as it matured into the late 70s was quite astounding, even though the transition from an awareness of adult education to adult education was quite marked. A significant number of talented and acclaimed authors and dramatists were engaged in adapting material for television, an effort that appears to have culminated in the wealth of British TV productions in the first half of the 1980s.

None of the programming of television has been as acutely well attuned to the informational needs of society as radio was in the initial post-war period. Information from radio was blatantly transmitted and consciously used as knowledge augmentations on the adult and school age population to meet the challenges facing Norwegian society at that time. That has neither been official policy in television, nor has it been the effect. To put a not too fine point to the argument, it is difficult to see what contribution in-depth knowledge about the digestive systems of Galapagos sea-iguana can make in solving the present lamentable state of employment in the country. Even the character of debate in Norwegian television has turned from the hour long lecture (that admittedly became intolerably dreary in the end) to the rapid fire of holster talk-show where nothing but irritation with both the audacity of the interviewer and subservience of the interviewed are perceived.

At this point in time we are at another significant cross-roads in the development of popular IT communication systems. I would venture the argument that the inherent apathy of television, that characteristic which makes it singularly addictive to the viewer, attractive to the investor, and aggressive to those it seeks to present, is its absolute monological way of communicating its message. In its most popular forms, it is no longer used as a significant source of information for discussion. People do not gather round the television as a group intent on information gathering. Its significance as a source beyond that of tomorrow's weather and traffic conditions on the way to work are minimal.

Clearly, the measure of success in the development and use of communicative

IT in the past has been its contribution to the way in which it disseminates the information necessary to meet important challenges in the society it serves. At this point in time that part of IT seems moribund in a profusion of radio and television channels that compete not for the serious attention of listeners and viewers, but for the more important interest of sponsors and advertisers. It appears that the ratings are a much more important measure of the significance of communication IT in society than the ability of that technology to contribute to the common problem-solving process.

Norwegian Telecom has traditionally been the carrier for all telecommunications and broadcast in this country. That is as it should be. It would be catastrophic if we were to be dependent on a conglomerate of carriers serving only a selection of broadcasters in the way the cable television companies have carved out their respective territories in various parts of the country. The same Norwegian Telecom is now peddling the mass communication technologies of the future. The reasons are many, but significantly without any conscious foundation in a public mission. When we first had a telephone installed in the early 1970s, there was a fairly long waiting period. The installation was costly. The initial down payment of several hundred dollars was extended as a long-term loan to the Telecom company which was used to build modern transmission systems in a country with an extensive and difficult geography. Now that we have one of the most modern cable and satellite based communication networks in the world, Telecom is eager to cash in on its investments.

Technologically, Norwegian Telecom has come a long way. It has not only grasped that digital communication is the foundation of both personal communication and public broadcast, it has also understood that it must somehow be involved in defining the role which many of the future forms of communication will take. On occasions where such services are presented, it is the technical side of matters that are presented as overwhelmingly important. While it is undeniable that the plain ability of glass fibre and copper wire to carry streams of data wide enough and quickly enough that determine the type of service that can be provided, it is the character and demand for that service which dictates its acceptance by those who will use it. It is often stated that all those involved in the use of future communications services will profit from them. Historically it is important to learn the lesson that "profit" in public communications systems is first achieved when the system matures to a state where it is perceived to augment the public level of knowledge contributing to social challenges.

Successful communication systems are not always those introduced by the public carriers. The telefax is a fairly good example. The success of the telefax is not perceived as being due to any active marketing by the international telecom carriers, but rather because of its popularity in ease of operation and added functionality over ordinary telephone lines. The fax, however, has all of the public communications appeal of the telegraph. Its greatest appeal is unattended personal messaging. Telefax is a communication technology waiting for electronic mail to "get its act together". Probably the most important lesson of the telefax "revolution" is that it is accepted by an ever increasing public not primarily for economic reasons, but for reasons of functionality and convenience.

Progress, far from consisting in change, depends on retentiveness. Those who cannot remember the past are condemned to fulfil it.

George Santayana, 1863–1952
Life of Reason (1905–6), vol.I, ch.xii.
Flux and Constancy
in Human Nature

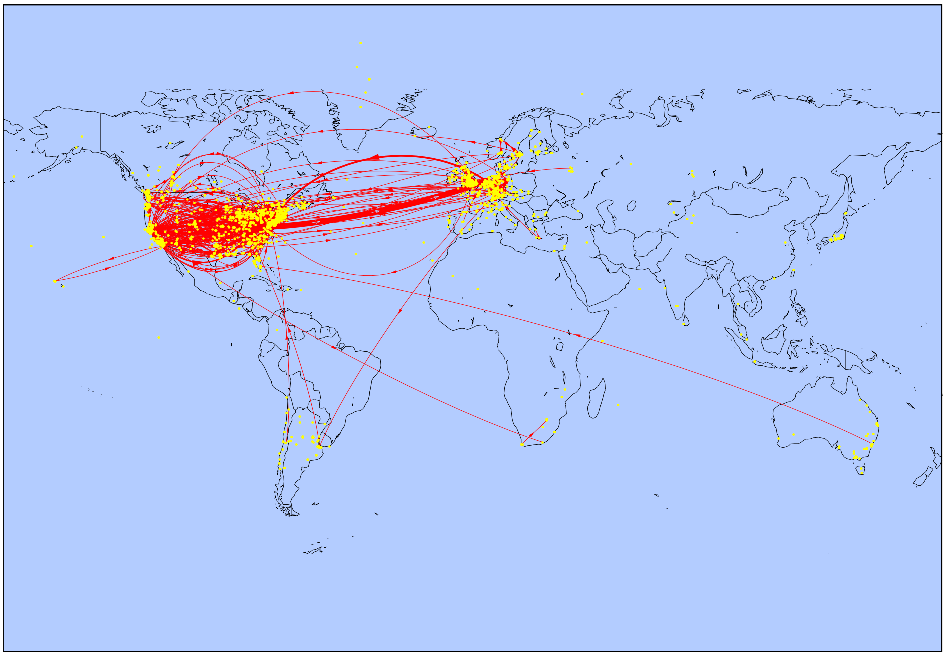

Figure 4 The aggregate flow of news on the Internet as registered at one particular point in time during the summer of 1992 (map from Usenet)

Interaction in public broadcast and personal communications

The last couple of years have seen developments in the relationship between digital communication technology and its application that should make the developers of IT systems sit up and watch. I am not at all sure of the consequence of the following observation, but we ought to be convinced that the implications are important: In 1935, president Franklin Roosevelt signed the Social Security Act (3), the tangible evidence of his New Deal policy. The challenges that appeared almost to overwhelm American society at the depths of economic and social depression gave rise to two significant and oddly inter-related phenomena. A time of deep and new-found social consciousness gave rise to an unprecedented use of information technology. For it was with the implementation of the Social Security Act that one of the greatest single efforts at data-gathering and processing was made. Computation was set to work for the public good on an unprecedented scale. Almost 60 years later, the United States government is again enacting legislation in the same two areas of social significance. Collective public and government concerned with reform of the American health care system is accompanied by quite significant public investment in national data communications systems where contribution to education and research are important expectations.

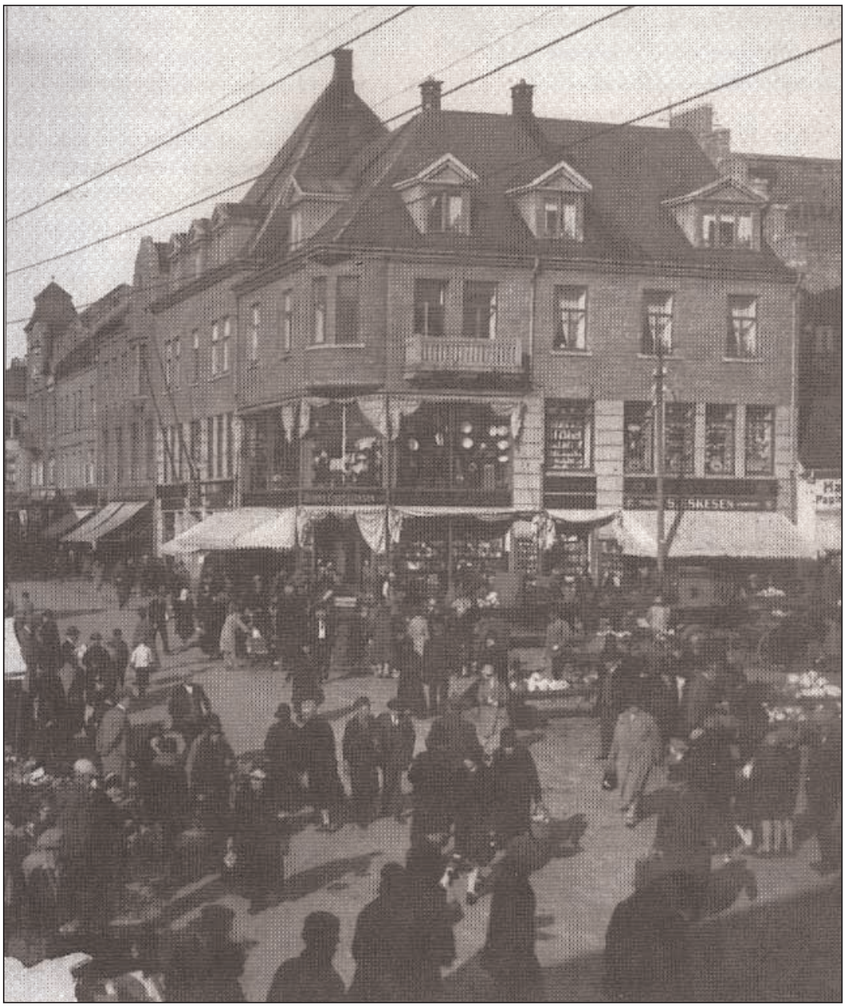

Figure 5 The cyberspace of public digital communication networks should also provide public spaces where people can meet and interact freely "Saturday shopping in the market in Fredrikstad on a sunny autumn day in the 1920s" (10)

To me, the single most important observation to be made from the above "coincidence" is the apparent (conscious or unconscious) lack of fear from transfer of informational power in the impending digital broadcast systems that will develop on the basis of the "highways of information" program. The reason for this may simply be the fact that American government has never been involved in using public broadcast for controlled information dissemination purposes. The result has been public IT communications system that entertains both the adulation and contempt of the American public.

In countries such as ours, where public broadcasting still commands some degree of respect, it is important that planners of future digital broadcasting pay attention to basic long-term effects in IT development as it relates to entire communities, rather than short-term interests. While lists of possible services including "movies on demand", credit ratings services, and so forth are singularly boring, mundane functions like file transfer and interactive, public information are often absent. As the most important innovator and contributor to the development of new communications technologies, Norwegian Telecom has the responsibility of injecting an appropriate measure of altruism in those services. It is also responsible for providing those authorities, public or private that have information on which knowledge can be built, with the necessary basic information on which to form their policies toward interactive broadcasting. For it is unquestionable that digital communications of the future will be interactive in various forms.

My own experience with a home and (remote) workplace wired into the international Internet on a 64 kb/s digital communications line has convinced us of the importance of a wide scale of interactivity in communications services. Our entire family has actively been using a local Ethernet with 5 computers, television in various degrees of integration. The single most important observation after half a year of immersion in a domestic digital information system is the personal satisfaction and sense of control that has come with complete involvement in the choice and contribution to the pool of information flowing in the net.

inconceivable in front of the television set.

So far, our experience seems to indicate that digital network communications ranging from personal interactive communication to one-way entertainment broadcast should be based on a few basic tenets.

- There should be a fundamental, altruistic policy of provision of information in the aims of any national carrier system.
- The carrier system should be publicly owned and run.
- Providers of information should be both public and private.
- There should be provision for public meeting places in the network.

Of the more important challenges to our highway providers is the policy of giving the lowest possible initial pricing to build volume and available information sources. Simultaneously, our politicians should duplicate the policies of the late pre-war and early post-war years of providing public libraries and forums for knowledge augmentation, debate and developing democracy.

Even though there is good reason to believe that great efforts will be made at creating lucrative markets for variations on arcade games and similar forms of entertainment, the fear should not be that vast sections of the public will inevitably become vegetables. Digital networks will certainly not look the way they do now, and they will most certainly be more than video games and TV shopping. If the popular press is to be believed, the public seems already aware of an alternative, "virtual worlds you can hook into – and get hooked on – are the latest rage on the computer networks" (4). And beyond the initial infatuations with entertainment in various guises will come the digital convenience and functionality of practising and sharing the common experiences and interests of everyday life with friends and like-minded both in the local community and the world at large. Wasn't that what we always wanted, but found postage stamps too slow at, and jet age pollutant travel too expensive for?

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Listen to Internet

BY PER E DYBVIK

681.324

Abstract

Computers connected in large global networks create a space, Cyberspace. The backbone of Cyberspace is the Internet, the world's largest computer network. Internet pilots advanced information services that are becoming an indispensible resource for a large number of users, both governmental institutions and commercial businesses. These services are different from those of the telecom administrations. This paper gives an overview of Internet and argues that the differences are due to different underlying philosophies and that we are witnessing a clash of cultures when the telecommunications and computer markets converge.

1 Introduction

> *"Cyberspace. A consensual hallucination experienced daily by billions of legitimate operators, in every nation, by children being taught mathematical concepts ... A graphic representation of data abstracted from the banks of every computer in the human system. Unthinkable complexity."*
>
> William Gibson, *Neuromancer*

The world's computer networks are constantly growing. Millions of users are connected in a matrix of computers making the visions of William Gibson's *Neuromancer* come closer. Company private networks, research and university networks, BBS networks and other computer networks are being linked.

The backbone of this complex network of computers is the Internet. The Internet is the largest computer network in the world. Internet pilots advanced information services which allow millions of users to communicate. Users may send messages to each other, search information databases, play multi-user games, and make new acquaintances.

Most computers on the Internet are found within the universities and research facilities, but the net is expanding into commercial businesses. The Internet has proved to be a computer network that has offered reliable and advanced information services. This fact is attracting interest, and for the last few years the Internet has become a meeting place for many governmental institutions and private companies. The Internet fulfils a need for advanced information services – services telephone companies around the world could not offer.

This paper will give an overview of the Internet; the history, they way it works, the services offered, and how it is organised.

Furthermore, some of the differences between the information services offered by telecom administrations and the ones we find within the Internet are discussed.

The last part of the paper looks at the future of the Internet.

2 What is Internet?

There is no clear answer to what the Internet is. The Internet may be viewed in terms of:

- A network of networks based on the TCP/IP protocols
- A community of people who use and develop those networks
- A collection of resources that can be reached from those networks.

To many people, the Internet is known to be an anarchistic computer network where anyone can do whatever they like to do. To some extent this is right. Nobody owns the Internet, so nobody tells you what to do or what you should not do. Internet is a general infrastructure offering different information services and an arena for experiments of new services.

Internet is probably best known to be a term used to cover all the TCP/IP networks that are connected. This network offers services that let users access information, ask questions, talk to each other, play games and send letters. The Internet is providing a network that has become a valuable resource for millions of users as an information network and place for social gathering.

2.1 History

The history of the Internet started around 1969 when the US Defense Department began research on computer communication networks through their research agency, Advanced Research Projects Agency (ARPA). They established the first four-node network in 1969 called the ARPAnet (later renamed the DARPAnet). The ARPAnet was an experimental computer network, a testbed for military usage. The aim was to build a network that could run even if parts of the network was damaged, e.g. bombed.

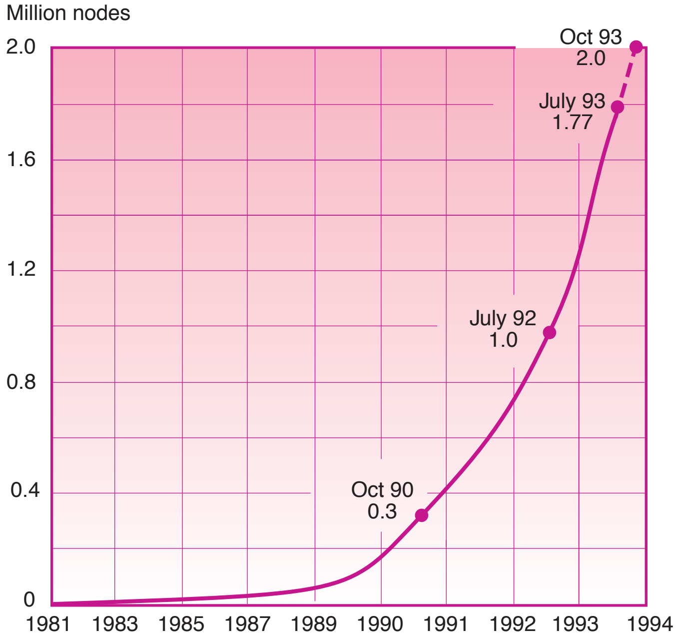

Figure 1 The number of network nodes (i.e. computers) connected to Internet (in millions)

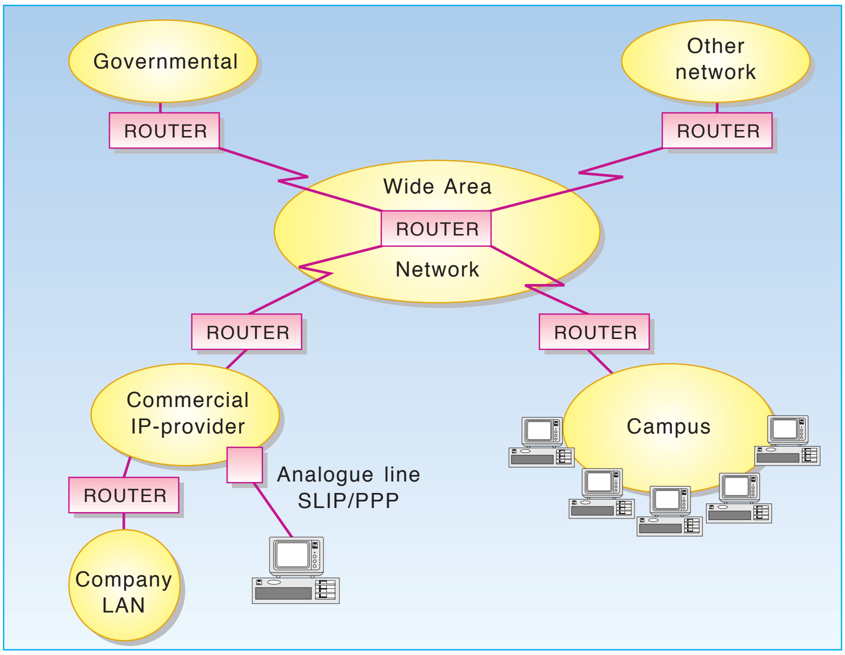

Figure 2 Internet is a network of networks using IP. Companies, governmental institutions and commercial Internet providers have their own IP networks that are interconnected

In the mid-seventies the TCP/IP protocols were developed for ARPAnet usage. Later, the ARPAnet was split into a military network and the network that we today know as the Internet. In 1981, Andrew S. Tanenbaum (11) wrote about Internet:

> *" ..., and has subsequently grown to well over 100 computers spanning half the globe, from Hawaii to Norway".*

The Internet started taking off in 1988 when the US National Scientific Foundation (NSF) established the NSFnet. It was meant to be a super computing network, but turned into the backbone of the Internet.

Since then, the Internet has expanded dramatically. The number of computers on the Internet reached the first million in 1992. By October 1993 this number has increased to about 2 million computers. The figures (33) show an increase of about 100 % annually. The Internet is also expanding geographically. Currently, the number of countries connected has passed 80.

Norway was one of the first countries to connect to the Internet. In 1973, three computers in Norway got connected through a 9600 Baud line. This connection was replaced in 1980 by a packet-switched satellite connection (34). By August 1993, there were over 25,000 Internet nodes in Norway. This number gives Norway the highest density of Internet nodes in the world with over 5,000 computers per million people. This is about 25 % higher than the US.

2.2 What does the Internet comprise?

The Internet is a network of networks (10)(12)(16). There are estimates showing that between 10,000 and 15,000 networks are included in the Internet. These networks are not connected to Internet, together they make up the Internet. The individual networks are run separately with their own system administrators, and are economically independent of each other. Each network pays for its own telecommunication lines, routers, and bridges.

Companies with their own Local Area Network (LAN) may connect to a regional or national Internet service provider. These service providers are offering services to interconnect company LANs, university campus networks, and also offer interconnection to international networks.

In Norway, Uninett AS, Telepost Communication, Datametrix and EUnet AS are offering IP services. TelePost Communication, a joint venture between the Norwegian Post Administration and Norwegian Telecom, offer commercial interconnection to Uninett and Swipnett. Uninett is connected to a Nordic Internet subnet called NorduNet. NorduNet is in turn connected to EBONE (European Backbone Internet) at the main host in Stockholm. EBONE offers several connections to the US (28).

The TCP/IP protocol suite is the fundamental that makes the computers all over the world talk to each other, independently of computer vendors. The foundation is the IP (Internet Protocol) (18) which routes the packets between different physical networks. Each computer connected to the Internet has a unique IP address. The IP protocol can run on most underlying connections like ISDN, X.25, Ethernet, Token Ring, Frame Relay, ATM, FDDI, and telephone lines.

One may argue that Internet is more than just the networks running TCP/IP. Services in Internet, like electronic mail, may reach out beyond the TCP/IP networks. Gateway functions make it possible to communicate with other networks not using the TCP/IP protocol suite. An electronic mail message may be routed from an Internet host through a mail gateway to a host connected to a network running other protocols.

2.3 The Internet services

The Internet offers a wide variety of services like electronic mail, file transfer, and bulletin boards. In fact, there is no overview of all the different services offered in the Internet. Most services found in the Internet are in the beginning only used on a small scale. As the services become known to the users in Internet, the services might develop into larger scale use. Some services never grow beyond a small group of users (7)(24)(25)(31).

The Internet can be compared to the traffic road infrastructure where the cars used in the infrastructure can be of every make from Unix workstations to PCs. Nobody asks you what you are doing on the road as long as you follow the rules. Nobody asks you what you are carrying and where you are going. You may start up a parcel delivery service to carry packages between Oslo and Trondheim. If one of the customers want that package to be sent to another place you might want some other parcel delivery company to do that for you. Then you have to

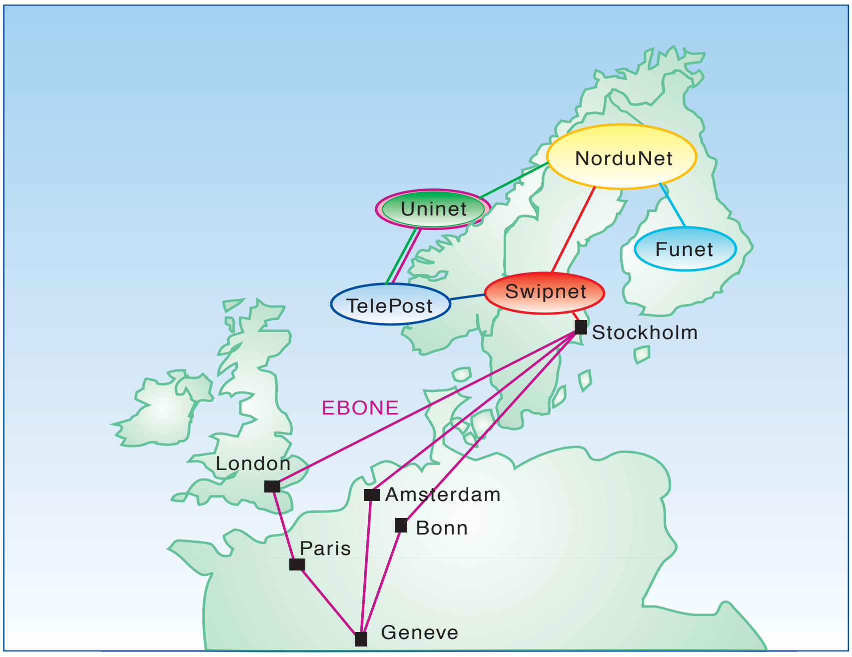

Figure 3 The European Internet infrastructure consists of several smaller regional and national networks connected to each other. The network highway through Europe is EBONE

gateway to that company by making the necessary arrangements.

The best known services in Internet are:

- *Telnet* is a terminal log-in service that lets users log in on other computers. The Telnet offers an ordinary text based interface to a remote computer where users may run other programs (20).

- *FTP* (File Transfer Protocol) lets users transfer files between computers (21). There are many databases in the Internet where users can pick up information like documents and images.

- *Electronic mail* is probably the most used service in the Internet. SMTP (Simple Mail Transfer Protocol) (19) is the native electronic mail protocol. In Europe, X.400 (a CCITT standard) is also widely used (5). Internet offers gateways between these two protocols as well as gateways to other mail systems around the world.

- *USENET* offers a bulletin board service where users may discuss different topics, post news and other information. The number of discussion groups is extensive. Several thousand groups cover topics from food and cartoons to communication protocols.

- *World Wide Web* (WWW) is a distributed hypermedia information system that lets users connect to a wide variety of databases all over the world. The WWW is based on a client-server model where the clients are communicating with the services through the HTTP (Hyper Text Transport Protocol). The HTTP is in fact an advanced file transfer protocol that lets the client retrieve documents from the servers. Today, WWW primarily uses HTML (Hyper Text Markup Language) to represent the information, but every format may be used as long as the client can interpret the information. One of the most popular services found in WWW has had an increase from 100,000 queries daily in June 93 to over 400,000 in October 93 (35).

2.4 OSI and Internet

When Internet was established, the Open System Interconnection (OSI) reference model (8), from ISO, was not ready. Many companies and organisations have adopted OSI, but until implementations of OSI are available, they use TCP/IP as an interim solution.

Some OSI application protocols have been taken into use on the Internet. The CCITT X.400 electronic mail protocol is heavily used in the European part of the Internet. Electronic mail gateways ensure smooth interworking of X.400 and SMTP (30).

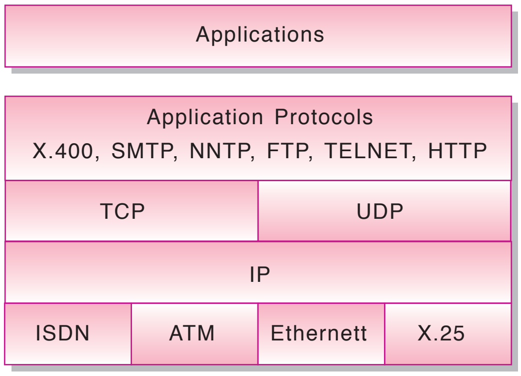

Figure 4 The Internet protocol stack

Internet has assigned several working groups inside IETF (see below) to investigate the interconnection of Internet protocols and OSI.

2.5 Organisation of the Internet

The organisation and development of the Internet has been carried out in different ways throughout the last twenty years. The enormous growth of the Internet has forced it to become more formal in the way it is organised. In 1992 the Internet Society (ISOC) was formed as a non-profit organisation to ensure further development of technical standards and foster a continued growth and evolution of the Internet. Underneath the ISOC is the Internet Activities Board (IAB) which has the responsibility for the overall technical development of the Internet. The Internet Research Task Force (IRTF) ensures that the long-term solutions are taken care of, while the Internet Engineering Task Force is handling the short-term development.

The IETF consists of volunteers who want to contribute to the standardisation of new protocols and services in the Internet. The IETF is split into different technical areas. Currently, these areas are:

- User services
- Applications
- Service applications
- Transport services
- Internet services
- Routing and addressing
- Security (27)
- Network management
- Operations requirements

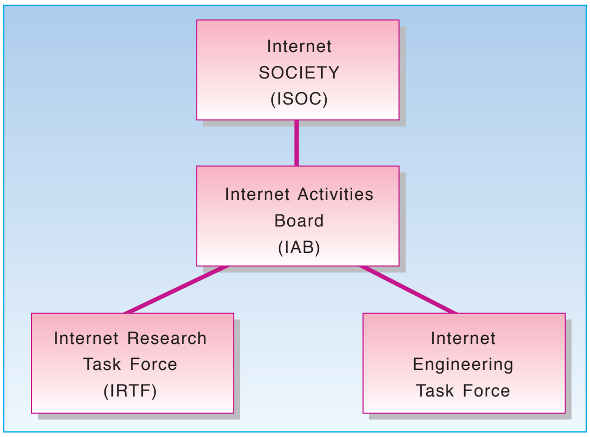

Figure 5 The Internet organisation

- Standards management.

The Internet Registry (IR), housed at the Defense Data Network (DDN) Network Information Center (NIC), is responsible for the administration and registration of the numerical addresses of networks and host computers (23). Another assignment authority is the Internet Assigned Numbers Authority, which assigns socket numbers, port numbers, etc. (22).

The standardisation of the protocols and other Internet technology is informal and different from the formal procedures of the standardisation bodies like ITU (International Telecommunication Union) or ISO (International Standardisation Organisation). The work of the IETF working groups are primarily done electronically and at the IETF meetings (3 meetings a year). Everyone contributing to the standardisation as a participant at a meeting or making comments online, is considered a member of the working group. The working group operates for approximately 9–18 months. After the working group has finished, the result is sent to the IAB for approval. The result is submitted as a draft-RFC (Request For Comments) for a brief public review (3). When it is approved it becomes a standard RFC and given a number.

3 Conflicting cultures

The telephone companies have long traditions of offering reliable and secure services. They are managing large and complex telephone networks. Their main focus has been voice communication services in the analogue telephone network. The telecoms have also played a major role in the establishment of a large number of computer networks by providing services like leased lines and X.25.

For the telecoms there has been a clear distinction between the computer networks, known as data communication, and the telephone networks. In the telephone network the users are offered end-user services like telephony and fax. On the data communication side, the customers – primarily businesses and governmental institutions – are offered services on a much lower level e.g. X.25 and Frame Relay.

The end-user services offered in the analogue telephone network and in ISDN are quite different from those offered in the Internet and in other computer networks. Computer networks have so far only considered asynchronous information services, while the telephone network has primarily offered voice communication services.

The distinction between data communication and telephony is disappearing as new digital technology is being introduced.

- Digital networks are replacing the old analogue networks offering higher bandwidth and new functionality.
- Computers are becoming important terminals for telecommunication applications replacing the telecom industries' dedicated terminals such as fax machines.

The distributed architecture of a computer network with general purpose computers is different from the more centralised telephone network. The packet switched architecture, found in many computer networks, opens up for a flexible way of introducing new services.

Why does it take years to implement an apparently simple service as a wake-up call into the telephone network ? To a computer programmer it seems quite simple, as it can be implemented with a few lines of code. The reason seems clear when we get to know that the software inside a telephone switch consists of several million code lines. All that code is fitted into a single proprietary telephone switch.

You will not find the same open systems philosophy among the telecom switch vendors as you will in the computer industry.

But telephone companies are changing their network architectures by introducing Universal Personal Telephony (UPT) and Intelligent Networks (IN). UPT and IN will attach numbers and services to a person, not to the terminal. The distributed architecture of UPT and IN will be very much like the architecture of computer networks.

Another clash of cultures have been seen on the end-user side between the computer industry and the telecom terminal vendors (13). The telecoms have had a tradition of making dedicated terminals with no other purposes than to support a single service, e.g. telephones, fax machines, and videophones. With the introduction of desktop computers this is changing. Computers are able to integrate video, audio, images and text – in fact they are able to handle telecommunication services like videophony, telephony, and fax in parallel (14)(15).

3.1 Packet switched vs. circuit switched

The introduction of packet switched technology in the Internet was a turning point. It brought with it aspects that changed the way people thought of information communication. Packet-switched technology was not only able to optimise performance on network level, it also introduced end-user services that could not be offered in circuit switched networks. Packet switching allows the information to be passed as small packets in the network.

Advantages of packet switched networks (1):

- The sender may send information even if the other end is receiving something else.
- The sender and receiver may have different network connections with different bandwidths available.
- Better utilisation of the existing bandwidth as more services may use the same physical line.
- The computer or terminal may be connected to several services at the same time.
- Easier to interwork with other networks.
- Packets may find other routes to get to the destination host even if some parts of the network is broken.

Disadvantages of packet switched networks:

- Current implementations of packet switched networks cannot guarantee a certain bandwidth disallowing the transfer of continuous media like video and audio. With the introduction of new network technology (e.g. ATM) this problem will be solved (26).

- The packets may cause buffering problems due to network overload. If the packets exceed the storage capacity of a network node, the packets may be dropped and has to be retransmitted.

3.2 Videotex and World Wide Web

The videotex service of French Telecom, called Minitel, has undoubtedly become a success. A large number of French households are currently using the service. The widespread use of the service is much due to France Telecom's policy of providing the terminals free of charge.

Videotex has not become the same success in other countries (6). In Norway there is a similar service: Datatorg. By mid-1993 the Norwegian Telecom's Datatorg had about 7,500 users – very few of them in households.

There are many reasons why the videotex has been a failure. The technology, developed in the 1970s, was apparently not designed to be used by general computers. No wonder why, since the affordable personal computer did not exist. Videotex was designed to be accessed by dedicated terminals with no other purpose than supporting that service. The main problem with the service was that there was no clear separation between the network, protocol, exchange format, terminal and the presentation. The user was not given any opportunity to customise a solution for his own need. The service determined the way the information should be presented and the way the user should interact with the service.

It is not fair to compare new services like the World Wide Web (WWW) with videotex even though they fulfil the same objective – to make information accessible to users over a network. Videotex was developed in the 1970s, while WWW has been developed over the past few years. The development of WWW is based on packet switched technology with an aim of presenting the information on a wide range of general purpose computers with graphical user interface capabilities.

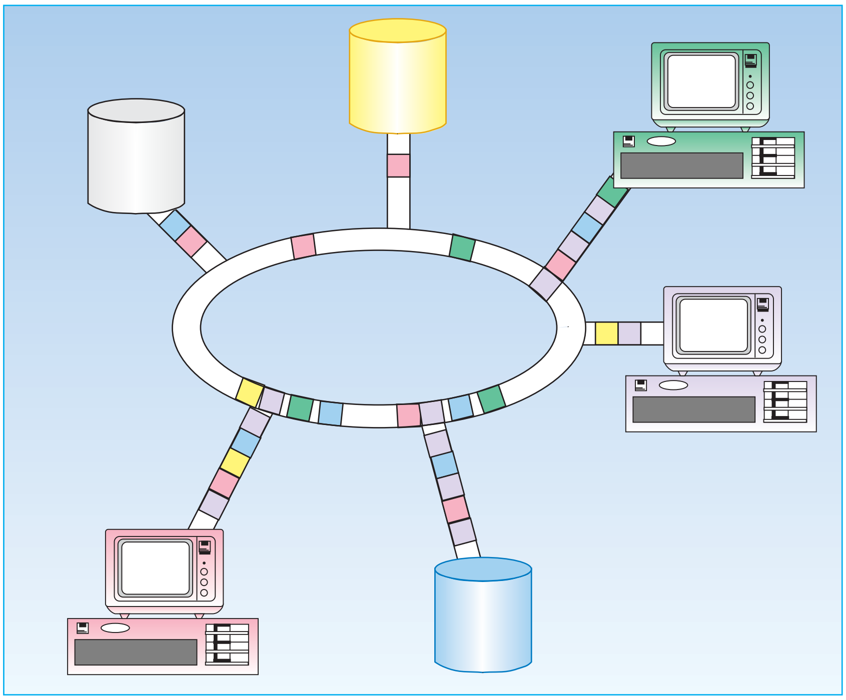

Figure 6 In packet switched networks the data are transmitted on small packets over the network. This allows several applications and services to co-exist and share the same physical line

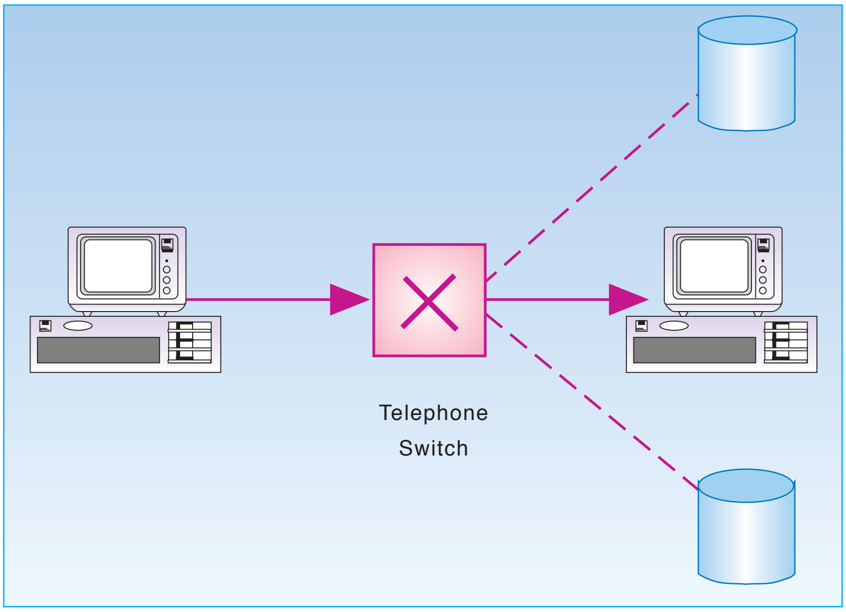

Figure 7 In circuit switched networks the connections between the user terminal and the information service are switched in the telephone switches. This does not allow several services to utilise the same connection – hence the connection has to be switched between the services

4 The future of Internet

"We think the Internet can have an impact far beyond the research and educational communities and help lay the foundation for the NII."

Vice-president Al Gore

From the very beginning the Internet has been financed by governmental institutions. The US National Research and Education Network (NREN) programme, a part of the High Performance Computing Act, was initiated in 1991. A part of the NREN programme was to upgrade the US Internet (primarily the NSFNET) to 45 Mbit/s. Vice-president Al Gore (email: vice-president@whitehouse.gov) has played a key role in these plans and also in the National Information Infrastructure Act of 1993 (NII) (see box) (2) (34) (4).

"Of course, these rates of growth cannot continue indefinitely, but there is reason to expect that the user population will exceed 100 million by 1998."

Dr. Vinton G. Cerf,
President of Internet Society,
March 23, 1993
about the future of the Internet

The success of the Internet is much due to governmental subsidies. Without the subsidies there probably would not be an Internet. The government plans to withdraw its subsidies to make users pay for the service themselves. Together with the fact that Internet opens up for commercial businesses, the financial structure will change. Internet is becoming interesting to commercial businesses because it can provide content. Many information providers have established themselves on the Internet and provide information and services that are becoming interesting outside the research and university communities (29).

AT&T has recently announced that they will offer Internet services. PSI has announced Internet over their cable network by mid-1994. US carriers Sprint and MCI already offer such services; British Telecom and France Telecom have announced commercial Internet services. In Norway, three Internet providers entered the market in 1993 (9).

There is reason to believe that Internet will expand into commercial businesses because businesses do not have other alternatives which can offer the same services.

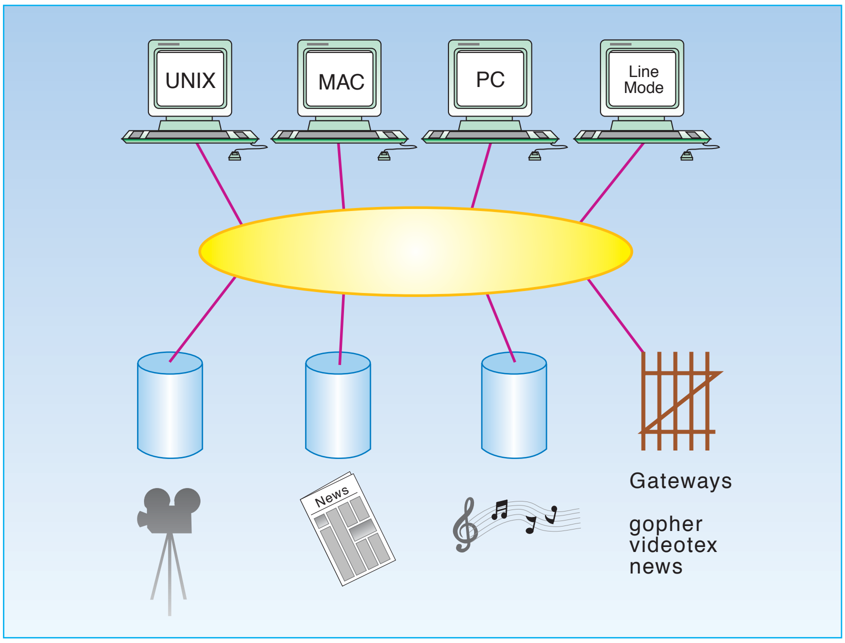

Figure 8 World Wide Web (WWW), an Internet based hypermedia information system, offers access to several different databases around the world. The databases contain all kinds of information like short film cuts, news, libraries, and music. With the flexible architecture of WWW almost all kinds of computer terminals can access these databases – of course without the possibility to present media types (i.e. audio and video images) not supported

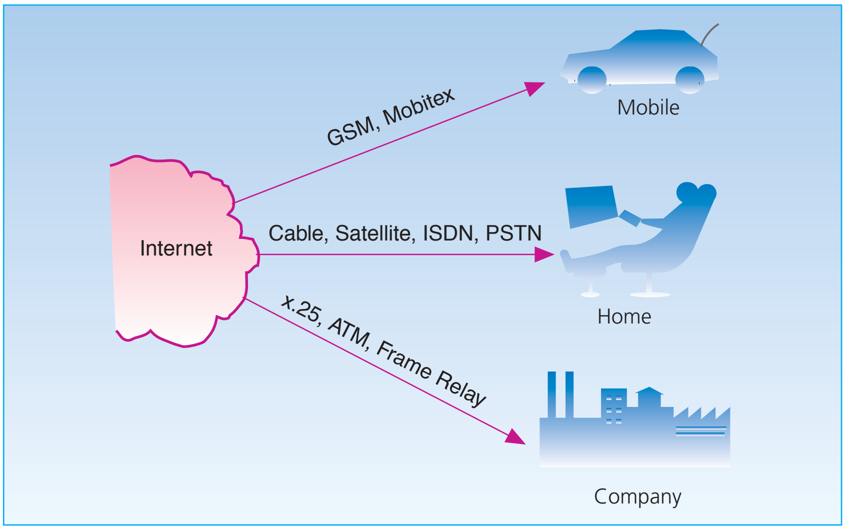

Figure 9 Internet is expanding and is reaching out to mobile users, the home market, and to businesses with high speed networks

4.1 Voice and audio communication

When President Clinton and Vice-president Al Gore visited Silicon Graphics in California earlier this year, their speeches were broadcast live on the Internet using video and audio.

The same system for audio and video transmission has been used to cover IETF meetings and also as a tool for researchers to communicate. The ESPRIT MICE project, where Norwegian Telecom Research is participating, is piloting Internet services for the com-

The National Information Infrastructure (NII)

The National Information Infrastructure (NII) is the ambiguous plans of the Clinton and Gore administration to create a national communication environment. The promise of the NII is to create an infrastructure offering advanced information services to all Americans, not only to research and educational institutions. The infrastructure is going to be offered to professionals, as a tool to their working tasks, and to all ordinary American citizens. The Americans shall benefit from the services by being able to get access to information databases, libraries, health care services, entertainment, and educational training.

> "All Americans have a stake in the construction of an advanced National Information Infrastructure (NII), a seamless web of communications networks, computers, databases, and consumer electronics that will put vast amounts of information at users' fingertips. Development of the NII can help unleash an information revolution that will change forever the way people live, work, and interact with each other."

The White House established the Information Infrastructure Task Force (IITF) to carry out the vision of the NII. Three committees of the IITF have been established:

1) Telecommunications Policy Committee will formulate a consistent Administration position on key telecommunications issues. This committee has recently created:
   - The Working Group on Universal Service, which will work to ensure that all Americans have access to and can enjoy the benefits of the National Information Infrastructure.

2) Information Policy Committee is addressing critical information policy issues that must be addressed if the National Information Infrastructure is to be fully deployed and utilised. The Committee has created three working groups:
   - The Working Group on Intellectual Property Rights, to develop proposals for protecting copyrights and other IPR in an electronic world.
   - The Working Group on Privacy, to design Administration policies to protect individual privacy despite the rapid increase in the collection, storage, and dissemination of personal data in electronic form.
   - The Working Group on Government Information focuses on ways to promote dissemination of government data in electronic form.

3) Applications Committee, which co-ordinates Administration efforts to develop, demonstrate, and promote applications of information technology in manufacturing, education, health care, government services, libraries, and other areas. This group works closely with the High-Performance Computing and Communications Program, which is funding development of new applications technologies, to determine how Administration policies can best promote the deployment of such technologies. So far, the Committee has created one working group:
   - The Working Group on Government Information Technology Services (GITS) will co-ordinate efforts to improve the application of information technology by Federal agencies.

munication of audio, video and shared workspaces.

The fact that you may now listen to the Internet is a threat to the telephone companies. When new digital network technology is introduced there is no technological barriers that prevent the Internet from communicating voice over a computer network.

5 Conclusions

The issue is not Internet vs. OSI, or some other technology. The issue is smooth interworking – information interworking.

It will get increasingly important to be able to communicate information across networks with different functionality and bandwidth, between different terminal equipment, and between users with different needs. The challenges of the future is to make all networks, computers, terminals, and services to co-exist.

The information services used on the Internet have proved to be a success with millions of users. There are reasons to believe that these information services will expand into other areas, both at home and in businesses. An increasingly larger part of the population are gaining skills and needs for such services as they are going through universities and other educational institutions.

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Telecommunications and CD-ROM – friends or foes?

BY ERLING MAARTMANN-MOE

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When CD-ROM was introduced in 1986, it was met with a deep scepticism from many groups within telecommunications and computing. I remember speaking to a conference in Norway in 1987 about our then pioneering first Nordic CD-ROM production, after the honoured guest at the conference, Philippe Kahn of Borland, had exclaimed: "In five years CD-ROM will be dead!"

The arguments against CD-ROM have been many and various: "Who has decided that 600 Mb is an appropriate upper limit for an electronic publication?"– "A storage medium that the user cannot store anything on?" –"Too slow!"– "It won't last forever!" (Who does?)

Still, five years after this conference – in 1992 – the estimated installed base of CD-ROM drives passed 3,000,000 world wide, and the number of available commercial titles passed 2,200. And it is really after 1992, with the evolvement of multimedia in computing, that CD-ROM really is taking off. Most PCs are now available in models with CD-ROM built-in. Software and documentation are often delivered free on CD-ROM, at extra cost on paper.

CD-ROM is established in the marketplace. In some senses it may be a competitor to telecommunications. Many on-line databases have CD-ROM competitors, catalogues and documentation that might have been available through networks are distributed on CD-ROM. When one of the guest editors asked me to write this article, I was encouraged to write about what telecommunications should offer to compete better with CD-ROM for such applications. To answer that, we need to know the CD-ROM.

So, what is a CD-ROM technically speaking? It is a round, flat piece of plastic, 120 mm in diameter, with a spiral track on one side that contains small bumps detectable with a laser and a mirror. These bumps are used to model bits, and according to the ISO 9660 – the standard that defines the CD-ROM characteristics – these bits are grouped together in sectors of 2336 bytes, of which usually 2048 are available to the user. Sectors are played at a speed of 75 per second, giving a data rate of 1.2 Mbit/s. ISO 9660 says a lot more than this; it defines file structure, error correction codes and so on, but the important thing is that this piece of plastic can carry a little over 600 Mb of data that can be retrieved in a little over an hour.

CD-ROM as a medium is physically identical to the audio CD that was introduced to the world market in 1984. The audio CD has been an unprecedented success in the consumer market. In fact, as far as I know only two products have wildly surpassed the (often very optimistic) prognoses made by American market research companies: The CD and the fax machine.

CD is neat

The CD was far better than the old LP in sound quality (though I know some persistent analogue freaks disagree with this), and initially the CD appealed to the high-end audio market of people with disposable incomes. But the massive success of the CD in the consumer market cannot be explained only by the audio quality, it is in my opinion due to another factor: Its *neatness:* It is lightweight, it is easy to treat, it looks good when you hold it up in the light, it is robust, and it is easy to use. These properties of the CD of course also apply to the CD-ROM.

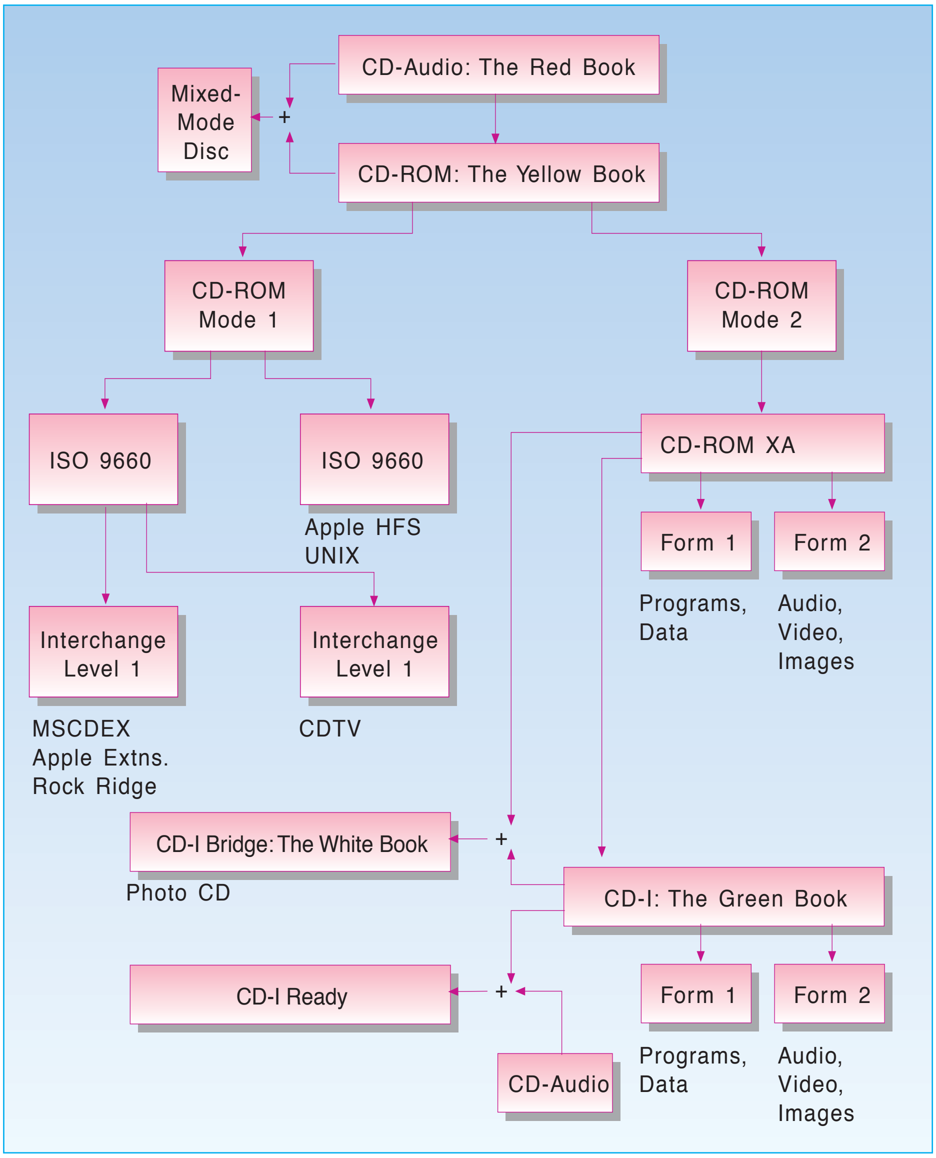

Figure 1 The CD family tree

CD-ROM is publishing

The initial scepticism to CD-ROM was in my opinion based on a misconception, or rather a lack of understanding of this new medium. Initially, CD-ROM was often referred to as an optical *storage* medium. This is not entirely untrue, but since the user could not *save* to CD-ROM (you can now!), this made the CD-ROM look like a strange animal.

From a user point of view, CD-ROM is not a storage medium, it is a *publishing* medium, and consequently useful only in such a context. For anyone distributing rather large volumes of fairly stable data to a number of users, CD-ROM should be considered as a platform.

Rather large may mean anything from 50 Mbytes to Gigabytes – a CD-ROM does not have to be full to be useful; on the other hand defining a volume consisting of several discs is no problem. Stable is also a relative question – some large financial databases are distributed with new versions on a bi-weekly basis to subscribers, but generally one would not publish extremely volatile data on CD-ROM. The number of users does not have to be large – if the information is of great value to a user group, it is possible to make a CD-ROM production viable and profitable with less than 100 customers.

Table 1 The data rate of a CD compared to other means of transmission. The second entry is a CD-ROM player with a transfer rate 6 times the normal rate. ATM is an emerging technology which first will be offered at 155 Mb/s. Surface mail is assumed to reach the recipient at 9 a.m. when posted at 5 p.m. the previous day

	Data rate	Time it takes to transfer a CD-ROM
CD-ROM	1.2 Mb/s	1h 14m
CD-ROM*6	7.2 Mb/s	12m 20s
Modem 2400	2.4 kb/s	25d 16h 40m
Modem 9600	9.6 kb/s	6d 10h 10m
X.25	64 kb/s	23h 7m 30s
ISDN 2B	128 kb/s	11h 33m 45s
2 Mbit	2 Mb/s	44m 24s
ATM	155 Mb/s	34s
Surface mail	?	16h

CD-ROM can be used for purely distributional purposes – moving files – or used as a vehicle for fully self-contained applications like an encyclopaedia. But it is not a *storage* medium.

CD-ROM is cheap

CD-ROM as a tool for professionals has the unique advantage of piggy-backing on a consumer product – the CD itself. Who would have thought in 1980 that a device containing a laser, a servo, an advanced D/A-converter and a power supply would sell for USD 100 upwards? The CD-ROM is a little more expensive than an ordinary CD player due to a more advanced controller, higher demands on data correctness and MTBF, and faster access times. But it now retails at USD 300 upwards.

The manufacturing process for CD and CD-ROM is identical for the disc itself, with a little higher quality demands for the latter. If you buy a Michael Jackson CD you get three things: The textbook, the plastic case, and the CD itself. In large volumes, the CD may be the cheapest of these three in pure production costs. For CD-ROM productions, it is possible to get down to less than a dollar per disc. Not much for 600 Mbyte!

Surprise: CD-ROM has relatively high bandwidth!

I think that one of the important aspects of CD-ROM when discussed in a telecommunications context is its *bandwidth*. A CD-ROM transfers 1.2 Mbit/s continuously to the desktop. That may not be impressive compared with a hard-disk, and CD-ROM is often regarded as a slow medium. But compared to available long-distance networks it is rather strong, especially since the kind of applications and data stored on CD-ROM often also are available in on-line databases in some form. Compared to most public long-distance networks like X.25 and ISDN, the bandwidth of CD-ROM is far ahead. In fact, it is so high that sending a CD-ROM by overnight mail gives the same bandwidth as one B-channel in ISDN – transferring 600 Mbytes in a perfect 64 kbit/s channel takes 21 hours! (See table 1.)

CD-ROM players have since the introduction considerably improved access and seek times, and lately also transfer times. Although in a strict sense violating the CD-ROM standard, the new players double or even quadruple the transfer rate of the CD-ROM by playing it back at a higher rotational speed, thereby achieving transfer rates of up to 600 kbytes/s or 4.8 Mbit/s. This works well for file transfer and for tailored applications, but of course not for audio and video intended for playback at normal speed, in which case speed must be set to standard 150 Mbyte/s.

CD-ROM is multimedia

Being "born" in the audio community, it is not surprising that CD-ROM is well suited for multimedia applications. Multimedia mixes the traditional data types like numbers and characters with audio, video, animation and MIDI data. In traditional applications data are *displayed* by the application, while in multimedia data are *played,* that is – time is an inherent property of multimedia data.

The distinct feature of the CD-ROM medium (contrary to for example a hard-disk) of having a fixed data rate, turns out to be an advantage in a multimedia context: A sustained, continuous and predictable data rate is guaranteed. This feature that is so essential to continuous media like audio, video and other time-dependent data types, is built-in for CD-ROM, while other channels like packet-switched networks and time-shared environments do not guarantee such a property without specialised protocols.

The CD-ROM format also allows for interleaving of data, so that one or more audio streams can be mixed with data and for example a video stream within each sector. This property assures synchronisation between different media, and also allows for software control of switching for example between different languages in an application. CD-ROM is now frequently used as a carrier for digital video in the form of MPEG, QuickTime or Video for Windows, and video can be played back directly and continuously with multiple channels of synchronised sound.

CD-ROM has no meter

A CD-ROM is sold like a book – you pay for it when you get it – using it is free. Contrary to telecommunications systems, there is no running meter, no expenses for information use or net access during use. This may imply higher initial costs, but on the other hand free use. It can be regarded as a mere pricing question, but it has quite deep implications in how users interact with the information. Browsing and exploratory use of the CD-expenses for information use or net access during use. This may imply higher initial costs, but on the other hand free use. It can be regarded as a mere pricing question, but it has quite deep implications in how users interact with the information. Browsing and exploratory use of the CD-ROM is encouraged by this pricing, while users in a net with running costs will tend to do things as quickly and goal-oriented as possible.

CD-ROM is standardised

The standard describing the physical format of all CDs, and the audio CD characteristics are often referred to as "The Red Book". CD-ROM was originally defined in "The Yellow Book" (also called the "High Sierra" standard after the hotel where the meeting was held), but it was standardised as ISO 9660 with minor modifications.

What the ISO 9660 ensures is just a common directory and file format so that the data on a CD-ROM can be read by any operating system with an ISO 9660 driver. A CD does not have to be made according to the ISO standard – both Apple and DEC have made CD-ROMs using proprietary file systems.

The standard defining the interleaving properties, plus some standards for audio (other than audio CD) and graphics, is called CD-ROM-XA, where XA stands for extended architecture. This format has become quite important because it is the basis of the Kodak Photo CD.

CD-ROM and the consumer

Special variants of the ISO CD-ROM requiring additional, proprietary add-ons, have been developed by Philips (CD-I), Commodore (CDTV), Kodak (Photo CD), and Sony (Data Discman). They are all special machines designed to be multimedia publishing platforms. None of them have so far had significant success in the marketplace, at least not sufficient to set a de facto standard for multimedia publishing. New, more powerful RISC-based machines like 3DO may have the power to become such a platform. Combined with the MPEG standard for video becoming available as cheap hardware decoders, full motion video will be an option on these players.

We do not know yet who will be the winner in this market, but they all agree on one thing: CD-ROM is the "paper" for multimedia publishing to the consumer market.

CD-ROM has become CD-RWM

Producing a CD-ROM in the late eighties was a rather tedious process: Files had to be prepared by the publisher, sent to a production house for formatting and pre-mastering on special equipment costing over USD 100,000, then sent on video-tape to a CD-factory for mastering. A process as complex as book publishing, and since a CD physically was stamped out in plastic in a print-like process, it really deserved the label *read only.*

Not so anymore – writeable CD-ROM drives cost less than USD 5,000, formatting software often included, and a blank disc costs around USD 30. A general user with an ordinary CD-ROM drive cannot alter the information, but production can be done in-house in small quantities.

For larger quantities it is still more cost-effective to have the disc stamped in a CD-factory, but an in-house written CD can be used as a master – just send it to the factory.

Kodak's Photo CD has also forced the CD standard to be changed so that information can be *appended* to a CD-ROM. The Photo CD is aimed at professional as well as amateur photographers, it can contain 100 very high-quality digital images, but customers are not expected to fill one CD immediately. One film may be 24 pictures, the next time the customer brings the CD and the new film, and the pictures are appended to the old Photo CD. Consequently, the standard had to allow for filling the unused space on a writeable CD, and this had to be reflected in the CD's directory structure. A *multi-session* CD-ROM drive is able to recognise such multiple generations of data appended.

In other words: CD-ROM is evolving. I would not be surprised if, in a few years, a new generation of CD-ROMs with 4 times the bandwidth and 2 times the playing time of the current CDs are on the market. These will be used for carrying MPEG-2 coded video of very high quality to the desktop and to the consumer.

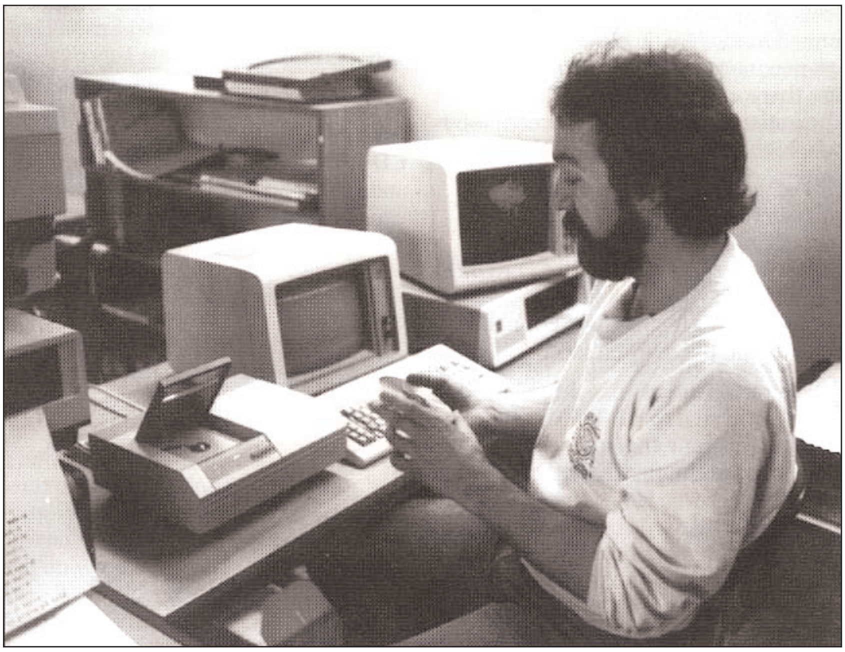

Figure 2 The author with the first Norwegian CD-ROM, an antique CD-ROM player, and a PC XT, in 1987. This CD-ROM was a co-operation project with Norwegian Computing Centre, the Norwegian Mapping Agency, the Central Bureau of Statistics, and Cappelen – a publishing house. The disc contained satellite images, screen- and vector-maps, demographic statistics, an encyclopaedia, and software

bandwidth access to a vast amount of multimedia information from the desktop in a neat and user-friendly way at almost no cost!

We know that telecommunications technology develop so fast that this may not be a very distant dream, technically speaking. B-ISDN and ATM, optical cables, new technologies for video transmission through telephone lines like Bell Atlantic's ADSL modem, infrastructures like the World Wide Web – they are powerful enough to make (at least the current) CD-ROM technology obsolete in the future. But this is not only a question of technology, the decisive factor will be availability, and above all: price.

What can telecommunications offer currently? It is not much quicker to log on to an on-line database, compared to installing a CD-ROM. By the way – CD-ROMs can also be shared within a local network. Bandwidth to the desktop within reasonable costs is limited to modem, X.25 or ISDN. That is a maximum of 128 kbit/s, which is less than one tenth of the CD-ROM. The initial equipment costs are generally higher than for a CD-ROM drive.

Few of the current network technologies offered can be called *neat,* they are generally not very user friendly to install and use, compared to CD-ROM. ISDN may have the potential to become such a technology, but needs to mature in the marketplace.

Telecommunications has three big assets compared to CD-ROM: Choice, updateability, and the option of two-way communication. Choice, because a user can browse in a vast world of information at will (provided the information of interest is not in a database that requires elaborate payment/user-id/password-procedures), without ordering and waiting for the physical arrival of a CD-ROM disc. Internet World Wide Web is an excellent example of how this can be done.

Updateability is the primary asset of telecommunications and on-line databases – the information is potentially fully updated, actual, new, corrected and so on. This is of vital importance to some types of information like pricing of goods, stock exchange rates and telephone numbers that change frequently.

Two-way communication is the third asset, which has the potential of coupling users together, for example by immediate response to marketing information, news, notices, requests, and so on.

These three assets should be utilised fully by telecommunications – in my opinion not to beat the CD-ROM, which is here to stay and has its strong sides. Rather, telecommunications should acknowledge the CD-ROM as an efficient carrier of vast amounts of multimedia information to large user groups, and enhance this information with telecommunications services.

It is possible for a CD-ROM application to have net connection integrated for ordering products, request updates, ask for additional information and services, send responses and opinions on products, connect to help desks, user groups and so on. Such enhancements are needed by many CD-ROMs, and would make them better products for the customer.

In my opinion, rather than seeing CD-ROM as a competitor, telecommunications companies should boldly use CD-ROM and enhance it with services and functionality that only networks can offer.

The digital video album
On the merging of media types in multimedia

BY GUNNAR LIESTØL

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The digital revolution in multimedia technology has only just begun. At present we know the basics of what the technology can do. Applications including these new features have been tested in isolated, controlled environments; but the real implementation in the world of mass users still lies ahead. The purpose of this paper is to look briefly at interrelationships between the fundamental qualities of digital media technology and the problems and possibilities it creates for semantics and conventions in the future genres of multimedia. With the concept of integration and its relationship to both distributed and isolated multimedia messages as a key starting point, the paper will touch upon the history of hypertext and hypermedia; the linearities of various media types and the idea of a digital video album. A last section will focus on some relevant features in a specific multimedia production.

The computer as a medium for other media

The development of information and media technology accelerates so fast that only the most dedicated and privileged are able to keep up with the process. The phenomenon *multimedia* is a field only vaguely defined. In this coreless territory perhaps the most unifying criterion is "newness": the fact that changes involved in this technology are mostly innovations; multimedia in its basics is *new* media technology. Soon we will certainly experience a more defined subject matter as institutionalisation in the field continues. For the time being the idea of *integration* may give us a valuable perspective. The Latin word *integer* means "unharmed", "whole", "undiminished". The verb *integrare* means "to complete"; *integratio* signifies "innovation", "restoring an ideal order". In sociology integration signifies the social relations uniting people in communities as parts of a whole as well as the condition of this wholeness. In the history of the electronic computer we experience integration at both the social, technological and informatic levels.

Ever since its emergence in electronic-digital form, the computer has been a meeting place of some kind. Like an agora, computer technology and environments have, in their different stages of development, constituted a place where persons, disciplines, media and information have converged and interacted. Starting out as enormous mainframe computing machines performing arithmetical tasks far beyond individual, manual achievements, the computer has developed into a small, relatively cheap but powerful tool marketed to millions of individual users.

Today, not only numbers, but words, drawings, pictures, sound, and video may be generated, processed and distributed by means of personal computers. The computer as we know it today has developed into a powerful and complex medium activating and forcing the use of multiple senses and capable of receiving, manipulating and transmitting all the traditional media types. Different media developed in distinct but overlapping and related institutions and technologies – such as painting, writing, print, photography, telephone, radio, film, television and video – now merge as digitally coded information in the hardware and software of microcomputers. Connected in global networks of end-users, the computer medium has constituted itself as a true super- or multimedium – a medium for other media.

Adding the digital machine's own capabilities of interaction and random access to vast amounts of information, this multimedia vehicle now represents the most technological advanced and complex medium in the joint history of human communication and information technology. Grounded on this infrastructure, we experience the emergence of a postprint, electronic-digital public sphere of only vaguely known structure, function and consequence.

Isolated resources and distributed environments

In hypermedia a distinction has been made between to kinds of system types: *resources* and *environments* (1). A resource is a large collection of read-only texts, for instance plain reference works like encyclopaedias or databases. With resources users may read, view, and copy the stored information. However, the information on the disc cannot be expanded as new material can only be added in the next edition. The hypermedia environment, on the other hand, is not constrained by read-only technology. It is an open and individual system where readers and writers share the same electronic environment and users may contribute with their own texts and link them in various ways to the documents already in the system. The hypermedia environment then becomes an ever growing and changing body of interconnected electronic texts. In these relations the idea of context gains new significance – texts no longer appear isolated and neither are they displaced from relevant and related contexts.

This relationship can be seen as parallel to the distinction between systems 'published' on physically unchangeable, isolated media, such as CD-ROMs, and, on the other hand, distributed systems based on electronic networks. This difference is important and will generate various conventions for composing multimedia messages. But although a fully developed network may have all advantages over publications of physical, unchangeable entities, the latter may still have a long life. Two thousand years of manuscript and book technology (followed by the success of video and audio cassettes) has instituted a market of producers and consumers where messages as goods are intimately related to physical entities. Despite the technical possibility of fully developed on-line networks, I believe it will take a considerable amount of time before the current mode of production will allow a radical redefinition of the individual message as a product and object. If the information commodity, in the form of electronic multimedia texts should only be available on-line, the text will loose its appearance as a concrete sensible object unambiguously pointing at its origin the author-producer. Since our western economic system seems to outlast every challenge from non-market economies, it is likely that the reification of information and knowledge existing in the age of the printed book will survive the transference to electronic, interactive media and thus for a long time favour the publication of units and genres compatible with this tradition.

The opposition between distributed and isolated multimedia messages is evident and will probably become more significant in the future. Though for the time being many of the problems we are dealing with in multimedia production, for instance the dynamic integration of media types and the establishing of meaning-effective conventions, are problems that need to be solved whether the messages are distributed over a network or published on a compact disc.

Hypertext and hypermedia

The terms hypertext and hypermedia were first presented in an essay by Theodor Holm Nelson published in 1965:

> "Let me introduce the word "hypertext"***** to mean a body of written or pictorial material interconnected in such a complex way that it could not conveniently be presented or represented on paper. It may contain summaries, or maps of its contents and their interrelations; it may contain annotations, additions and footnotes from scholars who have examined it. Let me suggest that such an object and system, properly designed and administered, could have great potential for education, increasing the student's range of choices, his sense of freedom, his motivation, and his intellectual grasp******. Such a system could grow indefinitely, gradually including more and more of the world's written knowledge. However, its internal file structure would have to be built to accept growth, change and complex informational arrangements. [...]
>
> Films, sound recordings, and video recordings are also linear strings, basically for mechanical reasons. But these, too, can now be arranged as non-linear systems – for instance, lattices – for editing purposes, or for display with different emphasis. [...] The hyperfilm – a browsable or vari-sequenced movie – is only one of the possible hypermedia that require our attention.
>
> *****The sense of "hyper-" used here connotes extension and generality; cf. "hyperspace." The criterion for this prefix is the inability of these objects to be comprised sensibly into linear media, like the text string, or even media of somewhat higher complexity. [...]
>
> ******I will discuss this idea at length elsewhere."(2)

These paragraphs introduce for the first time the terms and concepts "hypertext" and "hypermedia" and define them relatively close to the way they have later become known and implemented: as practices of interactive production, exchange and consumption of multiple media information by means of digital computers. Nelson's exposition of hypertext displays a double dimension. First, the verbal definition by means of concepts, but at the same time a demonstration. By attaching the five asterix signs "*****" to the (first use of the) word "hypertext" and to the corresponding footnote the reader is asked to transcend the linear order of the main text and jump to another textual level, to be found at the bottom of the page, for further explanations of the meaning of the prefix "hyper-". Nelson's definition then is not only based on the linguistic information but at the same time activates and implies the actual action it seeks to describe. By de facto being forced to move over the main text when reading from "hypertext" to "The sense of *hyper-*" – by following the rules and conventions of the footnote paradigm of the textual organisation – the reader accomplishes a double exposition, the verbal description and in addition the action of following a link. Thus, this piece of text and the rules that govern its use become a self-reflexive structure that does what it says and shows what it tells. This feature points to the potential of indirect communication in hypertext and hypermedia, where the shapes of electronic texts gain semiotic significance.

One might object, then, that hypertext is basically a paper based textual form implemented in book technology through features such as footnotes, references, allusions, etc. Although hypertext frequently has been described and explained as "the generalised footnote", the second footnote in our quote shows the limitations of textual interconnections in paper-based technology compared to the qualities of hypertext. The second footnote is a reference to something that is not there, unavailable to the reader, an elaboration which exists "elsewhere", outside the present paper.

Nelson uses hypertext and hypermedia at distinct grammatical levels. Hypertext, hyperfile, and hyperfilm are mentioned as examples of hypermedia. Hypermedia then becomes a generic term and not the name of a kind of hypermedium itself. The "hyper-" prefix denoting non-linear organisation of either text, pictures, sound, or video, is here thought of as a structure implemented in the separate media, not a device for linking across platforms. Later, Ted Nelson has adjusted his point of view and according to what is now common usage let 'hypermedia' be compatible with 'hypermedia document', 'hypermedia production', etc. Today, hypertext and hypermedia are being used as synonyms since 'text' is applied as a metaphor for all kinds of media types not just verbal text.

Before Nelson, the now classic paper by Bush (3), and Engelbart (4) were conceiving and implementing similar ideas – Bush in an environment of analogue mechanics before and after the 2nd World War and Engelbart as the first to radically explore the potential of the digital computer. Within the frames of Engelbart's strategic project on "augmenting the human intellect", most of the features on any modern microcomputer or workstation were developed: text editing, windows, the mouse, hypertext, outlining, groupware and e-mail. For both Bush and Engelbart as well as the later Nelson, the integration of media types was a major concern. Engelbart, for instance, demonstrated combinations of text, graphics and video on networked workstations as early as twenty-five years ago.

During the 1980s there was much talk about the future of multimedia and hypermedia, when only the supporting technological environments finally would be in place. During this period interesting projects based on combinations of analogue and digital equipment where developed, projects that also led to the establishment of conventions (5). In the early 1990s the technology gave sufficient support for full integration of audio and video on any medium range personal computer, especially the Apple Macintosh. The status of hypermedia today is not exactly what one would have imagined five to ten years ago. The all-digital environment is here, but real attempts of innovative integration of the various media types have still not shown up. Instead, one might detect a splitting in academic, lingocentric hypertext as one extreme and image dominated computer games as the other.

Media types and linearity

Ever since its introduction one of the basic characteristics of hypertext and hypermedia has been 'non-linearity'. The motivation behind non-sequential organisation of information has been to set authors and readers free from the linear slavery contained in written presentation based in paper and book technology. What does *non-linear* signify? Interacting with a hypermedia or multimedia document, users may choose their own path through the information to be consumed, thus constituting their own messages. The author-producer has not chosen one particular sequence of reading guaranteed by pages, chapters, and so on. We may say that the message presents itself with a non-linear structure, or without a primary sequential order. Does this imply that the whole hypermedia institution, the totality of production, text and consumption, and the rules that govern their use, on all levels display a non-linear structure? That would be an uncritical statement. Every conception of succession and order is in principle linear since it takes place in time. Reading and writing presuppose temporal and linear organisation and the stringent following of rules: the succession of letters constituting words, the succession of words constituting sentences, the succession of sentences constituting paragraphs, and so on. At one point in this structure it makes sense to talk about leaving a strict linearity, however, it is never totally absent, due to the temporal succession always present when generating and consuming information. The negating terms non-linear and non-sequential should then be substituted by the suggested multi-linear and multi-sequential (6).

This focusing on the problems of linearity gives us a perspective on the relationships between the various types of media. In the context of this essay, we may focus on four main media types: image, verbal text, video (moving images), and audio. In the perception and consumption of visual images there are no fundamental rules of linearity we must follow when exploring the image; which succession we go through to combine the elements into a whole, an image. Our gaze may travel relatively freely over the surface. Of course, there are limitations and structures which generate preferred readings of images, like foreground and background, constraints of light and shade, etc., but in general we might say that this is a succession or a linearity based on the subject's actions, a subjective linearity.

With written text it is quite different: if we are to generate the information and meaning invested in a written text at all, we have to follow the rules for reading written language. Vi must add letter to letter, words to words, sentences to sentences, etc. The rules of succession constituting writing are founded in language as an inter-subjective praxis among social human beings. We may then say that with the media type verbal text we are facing an inter-subjectively founded linearity. At the micro level this linearity

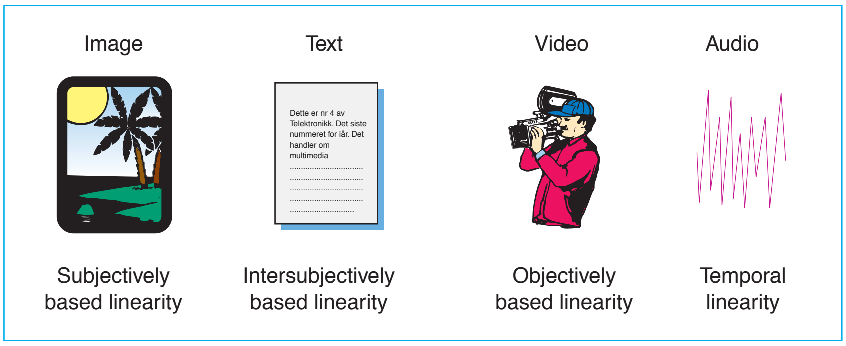

Figure 1

is necessarily very constrained, but the bigger the chunks of texts the less constrained and the less linear, and the more they may be consumed in multi-successive sequences. We do not read all texts from beginning to end, but feel free to jump back and forth, depending on our needs and interests. Writing at the macro level then, allows for a certain degree of interactivity as in encyclopaedias and newspapers.

With video (including television and film) we face a machinery which is presupposed before the media type starts to exist. The apparatus has to display a certain rate of frames, and the spectator must follow this flow of moving images, conditioned by time. A sequence can normally not be stopped; neither is it normal to choose the speed of consumption. The playback speed should be identical to the speed of recording. We may shut the apparatus down, but then this media type disappears as well. We may say that video as a media type is conditioned by an object founded kind of linearity.

Sound as a continuum is also dependent on an external source for organisation and existence. While image, text and video are visually based information, sound is aural. Audio information does not have the same potential of being selected, with sound space being reduced to the instant now, with a before and an after. Sound is thus an extreme kind of media type, and its linearity is a temporal linearity. Space may in audio occur as parallels of accords and harmony. These four media types find their places on an axis with the still image as the extreme space based exponent and with audio on the temporal side. Text and video are mixtures in between (see figure 1). Interactivity and the potential of selection are best when there is a space dominant modus supporting the subjective kind of linearity.

Integration of media types is not new in the history of media and communication. Writing and print technology have combined images and verbal text; and the silent movie changed from one configuration of multimedia (moving images + verbal text) to another (moving images + sound) when the talking movie was introduced. But these examples of integration are fundamentally different from what we might expect of computer based, digital multimedia. In literature, text usually dominates the image. The verbal text gives the ambiguous and meaning-rich environment of images direction and precision, rules on how to understand and use them. In the silent movie era text was subsumed under the speed and rhythm of the actions depicted in the film. Also, subtitles and text on television are always presented on the premises of moving images and their temporal linearity. In digital multimedia these relationships of repression and dominance do not have to exist, since the computer has the capacity to include and maintain the founding premises of each individual media type in integrated documents. The problem, however, is then to create a dynamic integration of the different sign types and still conserve their unique individual qualities without tending to dominance and subsumption. How can video and text be combined in a smooth way without the one dominating the other; or to put it another way: how can video be given qualities originally belonging to verbal text like a larger degree of selection and interactivity; and can text benefit from the video mode of linearity? The following discussion – related to the idea of a video album concretised in the production of a specific multimedia system – is a tentative attempt to provide some information about these problems.

Figure 2

A digital video album

In ancient Rome the word *album* (from Latin *albus* = white) designated the public boards with a white coat of chalk upon which were inscribed various messages and declarations to the public. The album served as a writing place on which individual documents were posted in manners similar to modern bulletin boards (both hard copy and electronic). This form of message exchange displays a contingent relationship between posted or inscribed documents. Each message was individual and self-contained, their common grounds were the group that produced them and the community that they addressed. The album format characteristically lacks a strict successive organisation of messages and meanings. Instead, its modern variant – the family album – tells stories by means of snapshots, and its effects have little in common with the constrained structure of linguistic articulation. On the other hand, the album generates the richness and variety of a pictured whole constituted by individual media clips as punctuations of time and place. Given the collage and montage elements of the album format and its multi-linear, fragmented structure it may serve as a metaphor for the composition of multimedia messages and their unconventional merging of various media and sign types. The family album displays a combination of figurative and verbal information as well as a fragmented, self-contained multi-linear order of organisation (although chronology often is a dominant principle). Each piece of information is autonomous and gives perfect meaning on its own, and is not dependent upon which information is consumed in the temporal context of before and after.

Facing the challenge of creating structure and form in a multimedia system – 'The Interactive Kon Tiki Museum'[1] – for presenting the excavations and expeditions of the Norwegian explorer Thor Heyerdahl, the idea of a video album was central. All Heyerdahl's major expeditions have been well-documented on film, photographs and in literature. But for a system planned as a supplement in the exhibition at the Kon Tiki Museum in Oslo, it was important to make much of the video available to the visitors. But the filmed material was all in the format of feature films or television documentaries which are not suitable for the museum environment and mode of information acquisition. The video material had to be made available to the users in short but self-contained chunks, and it had to be possible for the viewer to choose between various themes to get more detailed information on topics of their interest – still in the video format. Cross-references and linking in the video media, film and television are completely absent. One way of making video interactive was by adapting the footnote mode of reference, developed in literature, and use it as a model for how to organise the many chunks of specially edited digital video clips; but at the same time the dynamics, the rhythm and tempo of the whole presentation, had to be maintained. I will discuss these solutions in relation to the three following still images (screen shots) from the system.

The image in figure 2 depicts the scene in the system which corresponds to the table of content in a book or a magazine. In a time span of a couple of minutes, this scene introduces all the main topics or sections of the system. To introduce one of the items, four actions or sequences are joined to create a continuous flow or movement: The spinning of the globe, the marking of a path or a place, the zooming of an image from the geographic point to the button, then the short movie displayed on the button, before the whole sequence is repeated with the next button. These four different actions all contain different kinds of movement but are linked in a sequence to get the impression of a moving wave transported from the globe spinning to the movie icon (micon) on the button. This wave movement helps to create the impression of continuity, despite the discontinued elements and different types of actions involved.

The image in figure 3 shows the introductory scene to the Easter Island section. The two buttons named 'The Origins' and 'Statues' are the video footnotes. In literature, the convention of footnotes – the relationship between the main text and the footnote text – is marked with identical signs. Here, a different kind of pointing or suggesting relation was chosen. In the previous example the relations between the geographical point on the globe and the corresponding button were created by the

[1] *This production was funded and made possible by the joint collaboration of the Kon Tiki Museum, Department of Media and Communication (University of Oslo), The Norwegian Research Council, and Agenda Computing.*

movement of a growing image, starting as a pixel on the surface of the globe and ending as the first frame in a mini movie on the button. In the Easter Island scene this convention is more formalised. On the Macintosh, an animated frame indicates that a document is being opened. Following this convention, the image itself does not move, only an animated frame representing the reference to the video footnote.

If following the link to 'Origins' the whole screen changes and a new background appears with a blank field which does not display a video but text; three texts that like ingresses introduce the buttons to additional video clips (see figure 4). Instead of a time based media type like video introducing the scene, text alone was supposed to introduce the videos at this sub-level. However, this became problematic. When the user had got used to the dynamics of the two first scenes and their video based tempo and rhythm, something felt wrong when entering this scene. Suddenly, the user was facing text (a medium type with no intrinsic tempo for information aquisition) instead of video (with its object-based linearity). The dynamics of the presentation as a whole was gone, integration had not taken place in the intended way. Video had been supplied with characteristics from text. Now this had to be done the other way round; text had to be given the time dependent qualities of video. This was done in two ways. The text was divided into three paragraphs showing up on the screen in a sequence. Also, a voice over was added, an audio track reading the text. Thus the original non-temporal text was turned into a talkie, with changes over time both in the audio and in the video track. To achieve dynamic integration and flow one had to compromise a bit, the result was that video became interactive and selective like a text, and text time based like video and sound, but with the interactivity intact.

Conclusion

The video album as a synthesis of book and video conventions is only in its infancy of development. As a model and metaphor for the integration of media types in multimedia, it may still serve some functions. Another important aspect of the album is its mode of description. An album, non-linear and fragmented in its sequentially may depict a representation of a topic able to conserve

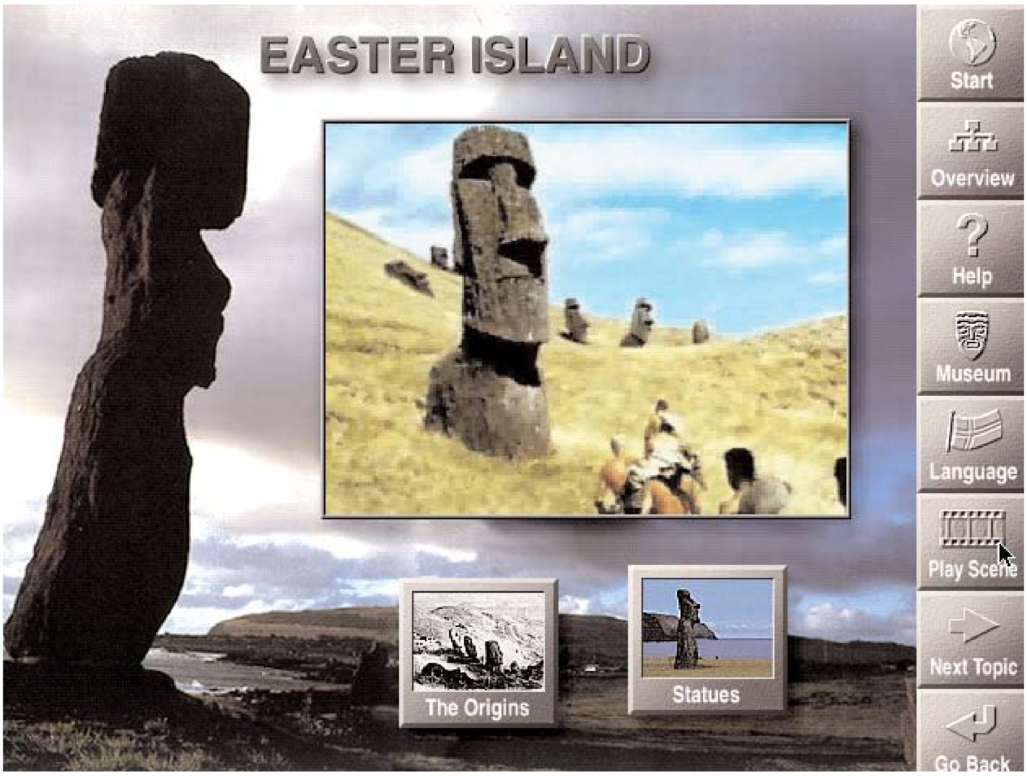

Figure 3

Figure 4

the multilevelled complexity of its subject matter. With the album format the message is not spoken or pointed at directly, but through a complexity of approaches and representations. The flexibility and multilevelled dimensions of such a format may have the capacity to level with communicative representational potential of future multimedia messages.

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Hypertext reading as practical action
– notes on technology, objectivation and knowledge

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Introduction

The concept of 'hypermedia' has perhaps superseded the actual technical steps toward such a technology. More is said about its revolutionary potential, than demonstrated. Both pioneers within hypermedia like Ted Nelson (who coined the term 'hypertext' in the 1960s) and literary theorists argue that we must abandon conceptual systems founded upon ideas of centre, margin, hierarchy and linearity, and replace them with the ones of multi-linearity, nodes, links and networks (Landow 1992, 2). Electronic texts are seen to include features which were never to be located in the printed book. The text opens itself to changes which automatically reduce the centrality of lines and chapters. It signifies the opportunity of non-sequential writing, to use one of Nelson's terms.

If this is correct, we need to investigate further what these new systems do to reader practices and what the reader can do with the systems. In the following, I would like to consider the transformations of the role of the reader hypertext seems to encourage due to the new hyper form of the text. My suggestion is that this new role enforces a new conception of reading and that hypertext reading can be better understood if we consider it as action, not very different from other actions and practices in everyday life. The new features of hypertext, the integration and the hyper aspect, change the role and the experience of the reader in that it enables stronger ties between the reader and the medium, which again may have some interesting consequences. In this light, we can also better grasp the historical process of objectivation (a term I shall explain later), which hypermedia seem to bring to a new level. Before that, however, I will consider some similarities and differences between telecommunications and the mass media, from which we can map the strange hybrid character of hypermedia; the merge of mass media like the book or television, and two-way and interactive media like the telephone or the database.

This article then, consists of three main parts: A) a discussion of the relationship between telecommunications, which results in hypermedia and other new media forms, B) a discussion of the nature of human action and interactive media like hypertext, and C) a discussion of objectivation of knowledge, that is, the inclusion and containment of knowledge in technological systems like hypertext. I will begin by considering some features of hypertext which make this medium intriguing in a socio-psychological and sociological light.

Hypertext is made of blocks of text – in the form of written text, pictures, video and sound, chained together by electronic links. The ambition of these systems is that the reader may browse through linked, cross-referenced, annotated texts in a non- or multi-sequential manner without becoming lost in the universe of texts, in hyperspace. The ideal, one may say, is order without linearity, or multi-linearity, multi-textuality (texts, animation, sound, etc.) and multi-sequentiality without chaos.

A full hypertext system enables the reader to select, rearrange and comment on the meta-text. One may choose one's own, individual reading paths, which make the 'book' a unique item. The active reader explores a text which in fact does not exist readily as a text until the reader composes it according to his or her requirements. In quite a different way than the typed text, the reader becomes more of a co-author, a new role which accompanies his role as a reader. Rather than simply reading a book, he *draws from* a book numerous of citations and put them together in new ways. The transition from typed text to hypertext is also a change from physical to virtual text, to potential textuality. In this sense, the author looses some of the control of his work, because the reader recomposes and makes it a new montage-like text each time. There is no given centre, and hence, no given hierarchy, of the narrative. The reader must make a centre from which he orients himself and investigates the text, or alternatively, he may 'travel' in the system, making use of various items of orientation, such as maps, menus, icons, and micons.

In the hypertext literature, the terms 'hypertext' and 'hypermedia' are often used interchangeably (see for instance Landow 1992). It seems to me, however, that the terms put the emphasis on somewhat different aspects of the new medium. Hypertext emphasises the integrational, and the hyper aspect: The first refers to the blending of verbal and non-verbal texts and the second refers to the possibility of multi-linearity and multi-sequentiality in the composing and reading of texts. The concept 'hypermedia', however, seems to refer more to the hypertext technology which the texts derive from, primarily the computer and the necessary additional equipment. From this, one may say that hypertexts stress the literary or textual element, whereas hypermedia stress the man-machine relationship, the relationship between the author, the medium and the reader. This, however, is far from a clear-cut distinction and the two aspects are of course mutually dependent on each other.

If we for a moment associate Marshall McLuhan's credo that "the media is the message" to hypertext, it is clear that the hyper-message goes through significant changes. The hyper-message seems to be more of a product of its technology, compared to the message in a typed book or on the television screen, in addition to being a product of the author. The message becomes a message only through the reader's wandering through sequences, links, and networks. The multi-linearity and hyper forms which the new medium enables, visualise clearly McLuhan's point: the text is no longer an isolated idea or argument delivered to the world by a detached author. Perhaps it never was like that. The hypertext is a fundamental socio-technological product – a merge of the mental and the material, of ideas and technology. In fact, hypermedia reveals that many commonplace ideas of messages, content, of texts and literature, are really historical effects of the specific forms of information technologies, from the parchment manuscript and the feather pen to the telephone and the hypertext computer. As also McLuhan notes, this fact becomes most evident when the medium is new and not yet interwoven with the assumptions in everyday habits and conventions. This is probably why hypermedia show its technological distinctiveness so clearly to us these days.

Another change is interlinked with the technological authority over the message. The electronic text is not an autonomous text like the printed text. Rather, it is one of innumerable possible *versions* of a typed text. As the message becomes a message only through the practice of the reader, the 'message is the reader', to rephrase McLuhan. The authoring function of the reader erodes the distance between the message and its reader as is present in the case of ordinary reading.

This means that the text is no longer simply an object as is the case with the typed book of text. The word 'book' refers to the text, the particular paper technology and to a physical entity. The book does not refer to a particular function, although we use books in functional practices like education, entertainment, etc. The book is an *object* to which the subject (the reader) directs his attention. However, this is not quite the case with hypermedia. Hypermedia is something more. It is also a *tool,* like the pen or the text editor. It is a tool of production, a tool of a special kind. It is a tool which enables communicative interactivity with the original author. We may compare it with the telephone, which is precisely a tool for communication.

Thus, the textuality is neither instantiated by the physical object of the book, nor limited to it (Landow 1992, 41). It cannot simply be called an electronic book since the text is not inherently unified with the computer (as the typed text is with the book) and since the text does not present itself in a ready-made fashion. Consequently, the user is not merely a reader in the commonplace meaning of the word. The user does not receive and interpret a complete unchangeable text, but applies an additional authorial role in modifying and recomposing the text into his text.

The hypertext computer is also a tool that must be instrumentally operated more actively and in a much more complicated way than in the reading of the book. And more important, it must be operated in a way that is much more intimately linked with the interpretation of the meaning itself. One may argue that if hypertext is composed in ways that are much closer to the ways the human intellect actually makes sense of texts, the act of reading, the reading as a practice, tends to approach the electronic structure of the text. This means that the act of reading and the text approach each other, even if they do not entirely merge.

As I will return to later, tools can be defined as 'material ways of doing things'. This definition stresses the action of the user more than the "thing" itself, because it is the use that defines it as a function, as a tool. An axe would not be a tool for the cutting of trees if no-one knew what it was for. Clearly, the hypertext computer is a tool, because it requires certain operations of the user in order to reach some ends. These operations with the computer as a tool proceed as an interactive process, where the user continually sees the result of each command or operation on the screen, from which he decides on new steps. The process is not very different from the cutting of trees or the paddling of a canoe with an oar. One central distinction, however, is that wood cutting and paddling proceed manually, whereas the wandering down the paths and passages of hypertext is manual/communicational.

I would like to argue that hypermedia merges these two forms of orientation, the instrumental orientation enhanced by tools, and the interpretative enhanced by objects of meaning. Through this blending of functions, it radically changes our conceptions of reading, writing and of what a 'text' is. And equally important, it involves new rules for meaning-constitutive practices of the reader. The reader becomes much more of an actor or agent, directing his competence and cognitive skills in and through this instrument/object. Our current vocabulary does not offer any appropriate terms for this new object/tool and its reader/user. I suggest that we simply settle for the term *media,* even if it normally refers to one-way mass media which does not require such interactivity. We should therefore be keeping in mind the two aspects of object and tool inherent in the medium of hypertext.

Ideally, hypertext enhances an active, selective and independent reader. However, in so doing, it also creates closer ties between the reader and the hypertext. The reader may select chunks of text from the meta-text and create links wherever he desires:

> "... it does narrow the phenomenological distance that separates individual documents from one another in the worlds of print and manuscript. In reducing the autonomy of the text, hypertext reduces the autonomy of the author." (Landow 1992, 71–72)

Some of this autonomy, according to Landow, is transferred to the reader. The reader is assumed as more independent, possessing more authority over the text. The active construction of meaning from texts that all readers are involved in, becomes extended even to select and sequence the very text itself. One may say that the reader collaborates with the author in producing a text by autonomous choices. This is also the case with a database search (Landow 1992, 75). It permits the reader to enter the author's text at any point and not at the point of the text, and so decide what is the 'beginning' and the 'end'.

Contrary to printed text, hypertext suggests integration and openness rather than self-containment. But precisely through this openness, it looses the quality of containing a truth, a definite message. The text is not a definite thing or object, but more like oral, evanescent utterances that constantly appear and vanish in flows of voices.

A) Electronic mass media and digitised telecommunications: Towards a unified media matrix?

To understand the background of hypertext, we should consider the two lines of technology and research that gave birth to it. Here, I shall particularly emphasise the social research on the two forms of media. Until the mid-eighties, telecommunications were largely ignored as an object in the field of media research, and so social and cultural questions related to telecommunications were largely left unaddressed. Apparently, the problems of telecommunications seemed to be merely technical, economic, and policy-oriented. Several theoretical reasons may account for this: *First,* media research was caught up with the explosive change within mass communication, particularly the electronic media. The growth of media research was legitimated on the cultural effects of media containing specific social and cultural messages.

Second, the field of media research was structured around theories and models dedicated to the particular structural features of *one-way mass* media and *mass* communication. There was an implicit tendency to view telecommunications as devoid of any cultural or political meaning "content-less" as they were. The structure of the media made it irrelevant to distinguish between powerful senders and dominated receivers of messages. Thus, the sociological topic of power was rarely pinpointed. Neither text- and gratification-oriented media research, nor cultural studies could 'find' any cultural content to analyse. The social and cultural impacts of telecommunications were impossible to grasp with models that assumed mass audiences and mass distributed messages. In the distinction between interpersonal communication and mass communication, the telephone and other communication technologies simply disappear, because they enhance communication in a fashion beyond both communication types.

Third, media research was not sufficiently connected to more general questions of modern change. For instance, the early days of media research did not provide perspectives on the successive transformations from face-to-face communication towards technical mediation of meaning. For many reasons, the insights of Harold Innis and Marshall McLuhan were (partly due to their rhetoric?) rarely seen as an important point of departure for further theorising.

Fourth, the most widely distributed and used telecommunications medium, the telephone, appeared "invisible" in everyday life. The discrete and mundane success of the telephone may also explain some of the lack of concern in media research for telecommunications.

A *fifth* reason for this lack of interest may be that the telephone has had a *feminine image,* deriving from its connection to women and the explicitly domestic. The telephone enhanced the widening gaps between private and public spheres of industrial society, and simultaneously provided means for female interaction. As a domestic medium, it became a "feminine" medium, available for home-working women with the expressive and integrating duties of the family in relation to relatives, other family members, friends, etc. Therefore, it is no coincidence that the emerging social research of the use of the telephone is closely connected to gender issues. (See Fischer 1992F, Martin 1992, Rakow 1992.)

Lastly, the development and implementation of telecommunication services is predominantly driven by a technical reason of engineers. The critical problem since the days of A.G. Bell has been the technical feasibility and improvements of the systems. In contrast, while also television is normally characterised as a 'high technology', it is fundamentally understood as a mediator of meaning and culture. Its technological features are seen as irrelevant compared to its cultural significance. Or rather, the cultural significance of mass media was seen as something detached from technology. Clearly, the diverging interpretation is related to the fact that the 'content' is created by the users themselves. Whereas mass media is dependent on a large, professional and highly innovative programming industry, there was no such industry in the telecommunications sector. No culture industry existed to balance the technological dimension. The considerable technical constraints in the telecommunications industry regarding diffusion of services, then digitalisation of the networks only enforced this. As one consequence, telecommunications, in spite of their role as mediators of meaning, were rarely discussed in relation to cultural issues.

Over the last decade, however, many of the distinctions between mass media and telecommunications have gradually evaded. This is due to technical changes in both kinds of media:

First, telecommunications adopt prestructured "content" with narrative meaning. Emerging trends indicate that telecommunication services extend its area from the strictly personal and interpersonal to the "mass" level. This results in three kinds of changes; in use patterns, technology and policy. The telephone and the telefax are used for distribution of standardised messages, as in marketing and fund-raising. "Junk-calls" and "junk-fax" and "junk-E-mail" clearly approach the principle of mass communication. In professional life, there is clearly a trend to substitute answering machines for "live" human voices. Voice mail and voice processing devices and messaging services may make it harder to reach a human being on the telephone. Instead, a standardised, preproduced message is presented. The similar trend can be seen in the increasing use of electronic bulletin boards, Videotex, and other databases and services as public information devices, and the coming service 'video-on-demand'. To the extent that hypermedia is linked to networks, they are certainly a prime example of the same. In the mid-eighties, one could readily refer to 'mass telematics' and telematic services as mass media without modifying accepted definitions of mass media. Telecommunications acquired preproduced "contents", available for an unidentifiable "mass" audience to interpret. While the traditional culture industry is not involved to the same extent in telecommunications, a software (and marketing) industry is expanding more than most industrial sectors. It seems like the information technology industry is developing a "culture industry" of its own. The increasing affiliation to software means that communication technology acquires a cultural 'content'.

Second, and related, is the trend of telephone conferences (Tele-markets, chat-lines, etc.), video conferences, and computer conferencing to *depersonalise* telecommunication. More indirectly, electronic surveillance in public spaces and databases containing personal data also suggest that telecommunications to a greater extent have collective significance in that they involve the "mass". Telecommunications prove to enhance group or mass meaning because they increasingly operate in junction with mass media. In distance education for instance, electronic media are normally combined with printed media.

Third, as telecommunications become deregulated, they find themselves in the political and the commercial heat: As they become subject for private initiative (due to deregulation), they also become noticeable as subject for political conflict, leading to various problematic dilemmas. For instance, freedom of expression hitherto related to the mass media, relates increasingly to Caller-ID, censorship of chat lines ("dial-a-porn") the French "messagerie", etc. To an increasing extent, they take part in the transformation of temporal and spatial conditions for social practices leading to ethical and political dilemmas. Just as the concept of 'public service' is at stake in broadcasting, the principle of 'universal service' becomes more visible for public attention when it is increasingly subject for deregulation.

Fourth, services based upon telecommunications increasingly join the matrix of media in domestic life and in the office. As the telephone receives new functions, computers, minitels, answering machines, and telefaxes find their way into the domestic market, they share a social context with the mass media. When telecommunications store messages of meaning, they escape evanescence. The growing use of technical equipment to enable storing of real-time media like television and telephone (answering machines, phone-mail, video recorders), erode the differences between real-time and asynchronous media. Certainly, the distinction between real-time and asynchronous media does not correspond to the difference between mass media and telecommunications.

Tools and objects – perceptive and hermeneutic mediation

All these socio-technical changes promote the perception of telecommunications, from something "empty", individual and technical, to something with a collective and cultural significance. The trends increasingly locate telecommunications (factually and mentally) in a new, shared media matrix.

And yet there are substantial differences. It remains a fact that telecommunications are normally interactive (as in the case of data-bases) and two-way directed (as in the case of telephone). Clearly, they require a different response from the part of the user than do mass media like radio or television. Apparently, communication technologies require a much higher degree of involvement from the user, as they open up for instant, interactive and immediate dialogical processes. The difference is often conceived of as one of different levels of commitment from the part of the user. It requires more initiative and conscious action to make a telephone call than to watch television. As the receiver also is a sender, (or rather, as the sender–receiver scheme renders obsolete) communication technology requires determination about the intentions of the process than the more habitual media reception. This is the case both if one is involved in an interactive process with a hypertext terminal, or if one participates in direct, communicative processes with others through the telephone.

However, the intuitive "observation" that communication technology requires a higher degree of determination than do mass media, only masks deeper and more significant user differences between the two kinds of media. However, the social and cultural significance of the various media is not explained by pointing out merely technological differences and similarities. Marshall McLuhan suggested a way of differentiating between media on a continuum between "hot" and "cold", according to their capacity to involve and engage the user emotionally (McLuhan 1964, 36). His idea was that while some media technologies furthered isolation and detachment from the community, others encouraged involvement into common affairs. The last kinds were those which resembled and simulated the direct, multi-sensed, non-linear and spoken communication patterns of the pre-modern village. From this, he derived that one-sensed, linear and visual media as printed media were "hot" media, in that they did not need the "warming" of the public. They favoured mental distance rather than involvement. At the other extreme of the hot–cold continuum was the "cold" television, (and to a lesser extent, other "electric" media) which promoted visual/auditive non-linear verbal communication. Hence, McLuhan's optimism derived from the appropriation of electric media at the expense of print media, leading toward a new tribal, "global village".

This distinction was not considered very successful. Suffice it to say here that the model relied primarily entirely on *mental* significance of the human sensorium as such, and less on the *social* and communicative relationship between the subject and human or symbolic objects. It was model of shared spirit more than of social solidarity. In the aftermath, it seems as the model was biased by the *a priori* aspiration to categorise the most powerful medium, television, as the promising new sensory and environment of human understanding.

Mass media enable relative *polysemy,* a cultural openness in relationship between producers and consumers: Along with (other) consumer goods and services, they involve cultural interpretation only relatively dependent on intentions on the producer side. Compared to telecommunications, cultural interpretation of mass media in everyday life proceeds more explicitly according to cultural values. The meaning inherent in telecommunication leans more to specific, direct and verbal constraints and response. Most telephone calls involve immediate co-ordination of meaning which can only take place in an ongoing conversation. The same is the case in computer-mediated communication. Although it would not be correct to label the telecommunication process a social *system,* it depends less on cultural values in society, and more directly on the immediate communicative interaction between specific individuals. It seems as in mass communication, on the other hand, the receiver possesses more interpretative autonomy in relation to the verbal message and less autonomy in relation to general norms, than do participators in telecommunication processes. In such processes the users are to a greater extent subjects, that is, producers of meaning that interweave, interpret, correct each other *directly*.

Consequently, it is often more appropriate to understand interaction through telecommunications as *one* interweaving interpretation process. For instance, rather than analysing a telephone call or computer-mediated communication as individuals delivering separate speech acts or 'notices', one should see them as interwoven and irreducible meaning-constitutive processes where contributions merge into mediation processes. This is one idea behind Everett Rogers' convergence model of communication (Rogers 1986, 200) and can also be traced to Bakhtins as well as Habermas' ideas of dialogue and communication. While both mass media and communication technology entail polysemy, the mass media present messages as something relatively independent of the producer and requires interpretative effort from the user. The interpretative space is more "cultural" than in the case of communication technology; they draw upon larger circles and more complex forms of cultural values. Hypertext seems to develop towards a peculiar hybrid of the two mediation mechanisms. It is more connected to an established 'work' of an author than is telecommunication, but leaves far more autonomy to the reader than do most mass media. It merges perceptive and hermeneutic interpretation forms.

Technology is always practically used, perceived or developed in relationship with a subject. As previously stated, the role of technology in agency can be categorised

a) as *tools* to undertake some practice directed toward some other human or material object (such as a hammer or a computer terminal). As Heidegger notes, the technology acquires meaning-as-tool. It "withdraws" so that it can be used *in-order-to* reach an other end (see also Sorokin in Østerberg 1990, 207)
b) as *objects* (such as a piece of art), with reference to culture and to which practices are oriented *towards*
c) as *contexts, in or at* which practices take place (factually, such as a room or a square, or dual as in the case of mass media, or virtually, like a telephone conversation).

Here, I wish to focus on a) and b) although the contextual element is increasingly important. In technology-mediated action involving tools, an inherent contextual and purposive junction between the agent and the medium is at play as opposed to the world on the other. This, however, varies inherently between technologies. I would like to argue that this addresses one of the most important differences between mass media and communication technologies. Whereas technology-mediated action/perception inherently unites the subject and the medium toward the world, mass media, as projections and images of the world, distance themselves from the subject. Thus, the subject – medium – world relationship is quite different.

Both cases are forms of mediated everyday practices that principally entail the dimensions of agency. However, whereas perceptional technologies like communication technologies involve action predominantly *towards the world through technology,* mass media involve predominantly action *towards the technology through the world*. It is from this we can distinguish between two different forms of social integration processes; *perceptive and hermeneutic integration*.[1]

I should here propose a preliminary definition of tools. With reference to Olav Asheim, Tom Johansen defines technology as "materially embedded (fastlagte) ways of doing things" (Johansen 1992, 123). The definition, which stresses technology as socially constructed, is wide enough to encapsulate both the particular historical technologies in different cultures and the changing of ways of doing things, that is, the rationality involved. The definition is closely related to the subject in the complex of agency, and thus suitable for our perspective related to technology-mediated action. However, while in all its generality it is hardly incorrect, it is insufficient. In my own terminology this definition suits more as a definition of tools, than of technology as such. This is because it does not address the significance of technology beyond the level of action. We may define tools as one aspect of technology and as material ways of doing things. Communication technologies as tools, implies material/communicational ways of doing things in an extended time/space.

B) Agency

A study of hypertext and technology-mediated action implies an analysis of the alternative possibilities of action and the potential consequences for the ones involved. It should account for implications and consequences of alternative compositions of text. Clearly, this is not the way media researchers normally think, which shows that the problems posed by the new media differs substantially from the ones normally posed in mass media research. While it can account for some of the non-subject and non-technological aspects of the new media, i.e. through textual analysis of databases and computer conversations, it cannot explain the position of the subject in relation to the medium and co-subjects.

Thus, it seems like the use of the communication technologies most of all constitutes a theoretical challenge to theories of *action*. What we may call *technology-mediated action* constitutes an expanded and more dense dimension of social action in advanced societies. Only by relating the use of communication technology to sociology of action, of *using* in day to day life, one may profit from both media theory and theory of technology. Exploring the nature of technology-mediated action involves a sociological inquiry of contemporary forms of action orientations. The next step is therefore to relate such tools to the acting individual.

The tool, the context and the knowledgeable agent meet in *agency*. In the following I will discuss agency from different perspectives. Central here is the understanding of agency as composed of subject, tool and context in practical everyday conduct.

Let me start by considering some conceptions of action in sociology. The basic object of sociological enquiry, according to the prominent British sociologist Anthony Giddens, is neither the subjective experience of the individual actor, nor "society" as a social totality (Giddens 1984). Rather than focusing on subjectivity or objective structures, one should connect all aspects of agency and relate them to social change. This is because practices are not just created by the individual actor, but reproduced objectively in ways that confirm the subject *as* subject. Social life is reproduced

> "... in and through social praxis, understood as nature, conditions, and consequences of historically and spatio-temporally situated activities and interactions produced through the agency of social actors." (Cohen 1989, 2)

In and through their own re-creation, practices recursively reproduce conditions for future events. To Giddens, the notion of intentionality may overstate the rational aims of the actor. The role of the actor should be understood in terms of knowledgeability and capability; her power to produce effects, and her awareness of her capacity to achieve outcomes (Giddens 1984, 257–258):

> "To be an agent is to be able to deploy (chronically, in the flow of daily life) a range of causal powers, including that of influencing those deployed by others. Action depends upon the capability of the individual to "make a difference" to a pre-existing state of affairs or course of events." (Giddens 1984, 14)

Giddens' theory represents an attempt to balance individual preferences for action with collective norms. As Cohen points out, Giddens' theory involves a "decentering" of the subject in favour of a concern for the nature and consequences of the activities in which social actors engage during their participation in day-to-day life (Cohen 1989, 11). Thus the processes of practices as such are more central to Giddens than the actor herself. Though the subject is the interpretative agent who produces social life and its events, daily practices may be carried out without being directly or discursively motivated. They are neither carried out with the automatics of natural processes, nor with perfect consciousness. Social practices are recreated with what Giddens calls human knowledgeability, normally in the form of tacit knowledge. They are a part of the "flow of life".

However, this does not imply behaviourism or any other theoretical reduction of the subject. The acting and knowledgeable subject is vital to an encompassing notion of agency. *Agency involves not only practices and interaction as such, but also the conditions, forces and means of action.* The theoretical convenience of the notion of agency is that it involves much more than the actor him-/herself. Agency equates the constitution of social life, that is, all elements involved in, and conditions for action. This broad notion of agency is motivated by a concern in the theory of structuration to express the entanglement of individual and collective action, as well as the inherent connection between the conduct and its conditions.

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[1] *One could somewhat roughly speak of perceptual integration as social integration, and hermeneutic integration as cultural integration because the first kind mediates perceptionally between human beings, that is, enables social interaction, and the second kind mediates general cultural values. The first kind involves tools in technology-mediated action, and communication-technological mediation.*

Agency may be both individual and collective. As Sewell notes, it entails the ability to co-ordinate one's action with others and against others. Social movements for instance, are agents of themselves, and they are important foundations of individual agents.

> "Agency characterises individuals but the agency exercised by persons is collective in both its sources and its mode of exercise. Personal agency is, therefore laden with collectively produced differences of power and implicated in collective struggles and resistances." (Sewell 1992, 21)

Power means to possess transformative capacity. Thus, the power of agency means the capacity to intervene in a course of events or in a state of affairs, which requires "causal powers" including tools. Through the capability of the actor to "make a difference" as an inherent feature of agency, social practices always mediate power, and are always oriented towards potential change. An actor may in principle always change a course of events or a pattern of interaction. To speak of agency means that the individual could have acted differently:

> "Whatever happened would not have happened if that individual had not intervened. Action is a continuous process, a flow, in which the reflexive monitoring which the individual maintains is fundamental to the control of the body that actors ordinarily sustain throughout their day-to-day lives."(Giddens 1984, 9)

This is implied in the recognition of social agents as knowledgeable and with practical (or even discursive) consciousness. The production of social life is a skilled performance even if the skills are only tacitly recognised. The two forms of integration (perceptive and hermeneutic) involve two kinds of user power. Clearly, they are both devices of power and control. But the power of the user of communication technologies reach beyond the on/off ritual, the opinion leader function or to the hermeneutic practices of media reception. The power to intrude, awake, register, harass, collect, survey, process, and distribute information, puts the user of communication technology in a critical position within agency because they precisely enable the power to change the course of distanciated events, to intervene into social processes in extended time/space.

As Giddens, the French sociologist Pierre Bourdieu attempts to transcend the usual emphasis on individual choice while not relapsing into the contrary position of structuralism (Bourdieu 1977, 1990). He wants to overcome both determinist and voluntarist images of action. Both modes of knowledge are equally indispensable to the social sciences, but to apply the insights of both, they must be transcended.

For example, what is economically sound or most efficient may not be what guides individual action in practical life. Tradition and culture developed under different conditions continuously guide action where they are not economically rational. And reversibly, the symbolic character of practices may be as important to the reproduction of a social formation as their material character. Thus Bourdieu wants to develop a mode of knowledge and practice that is genuinely *practical*. Rather than defining action internally (choice) or externally (structure), Bourdieu wants to explain the dialectic of *incorporation* and *objectivation:* The internalisation of objective structure (culture as well as materiality) and the externalisation of internal competencies. Only in this way, one can understand social order *and* social change.

The principle of habitus

The concept of *habitus* represents the crux of this argument. Habitus is the social logic of which daily practices are guided. It coins the 'rationality' of everyday practices. One may conceive it as an ethos or disposition that orient practice according to an unrecognised symbolic economy, but it is also a principle of social and cultural competencies of the individual, adapted creatively to specific contexts in everyday life. It reflects the social condition under which it is unfolded, but it also leaves space for individual variability in thoughts, perceptions, and actions. It represents the 'collective unconscious' and defines the repertoire of action in specific contexts. It neither guides automatic ritual, nor autonomous choice. Rather, it composes practical conduct by mediating between the internal and the external, for instance between personal style and collective norms. As Thompson holds,

> "To a large extent, the rules and conventions which guide much of the action and interaction in social life are implicit, unformulated, informal, imprecise. They may be conceptualised as flexible schemata which orientate individuals in the course of their everyday lives, without ever being raised to the level of explicit and well-formulated precepts. They exist in the form of practical knowledge, gradually inculcated and continuously reproduces in the practices of everyday life, in much the way, for example, that conventions of cleanliness or good manners are inculcated from birth." (Thompson 1990, 148)

In socialisation processes, the individual adapts new experiences to already internalised sets of preferences that then also become affected. Habitus is a product of socialisation in an established cultural order. Miller emphasises this when he defines Habitus as

> "... that structured set of classificatory schema which is inculcated in the child as its sense of cultural propriety and normative order." (Miller 1987, 103)

Patterns of morality, exchange relations, architecture, art and other approximately established cultural systems become part of the individual's personal competence through social interaction. Habitus thus mediates between material conditions and practices of social segments. It represents a constructionist competence that is systematically differentiated in society, and unites and separates social groups. The dialectic of Habitus is amply expressed in a definition of habitus as:

> "... systems of durable, transposable *dispositions,* structured structures predisposed to function as structuring structures, that is, as principles of the generation and structuring of practices and representations, which can be objectively "regulated" and "regular" without in any way being the product of obedience to rules, objectively adapted to their goals without presupposing a conscious aiming at ends or an express mastery of the operations necessary to attain them, and being all this, collectively orchestrated without being the product of the orchestrating action of a conductor." (Bourdieu 1990, 72)

And similarly:

> "The habitus is the universalising mediation which causes an individual agent's practices, without either explicit reason or signifying intent, to be none the less "sensible" and "rea-

sonable". That part of practices which remains obscure in the eyes of their own producers is the aspect by which they are objectively adjusted to other practices and to the structures of which the principle of their production is itself that product." (Bourdieu 1990, 79)

The cultural principles that constitute a habitus are socio-economically differentiated, for instance in terms of gender, class or urban/rural background. The habitus therefore tends to reproduce social differences through defining and homogenising cultural boundaries. This sociological fact represents the structural or given side of habitus. In the area of cultural consumption, cultural capital (based on time invested in obtaining cultural knowledge) structures levels of habitus and the following differentiation of taste (Bourdieu 1990, 80).

And yet reproduction is entirely dependent on individual interpretation of established classificatory systems, resulting in various practices that can only be understood subjectively, through a constructive approach. Bourdieu's perspective enables a view on structured sets of dispositions, and their consequences for the reproduction of power and social control without relapsing into objectivism. Social change are accounted for through the emphasis on indirect, embodied rules that regulate action. There are no other structuring than the reproduction of conditions that reproduce cultural homogeneity (Bourdieu 1990, 80). Objective structures are themselves products of historical practices. Although socio-economic structures can be seen reproduced in cultural practice, (as can easily be demonstrated through statistics), modified practices and "readings" of the world always break away from hegemonic patterns.

The principle of habitus has been applied to a number of areas of culture by Bourdieu and others. It helps to explain how and why specific cultural patterns reproduce themselves. It connects culture with social control because it exposes the relationship between cultural practices and economic and cultural capital. In media research, for instance, it clarifies that there are not only different things to select from on television, there are also different ways of seeing and understanding television content, which co-varies relatively with the capital-differentiated habitus. The hermeneutic point of *meaning* is refined and connected to socio-economic analysis of audiences, and the incorporation of stratified life conditions can then be traced in the social use of the media. Though the use and understanding of media content are individual and unique, it also demonstrates inscriptions of structural distinctions. The embodying of cultural-economic structures in individual dispositions may provide systematically differentiated cultural media practices.

Bourdieu's position relates the unconscious reproduction of class divisions by individual practices in various situations. This structural aspect of practice is thus invisible for us in daily life, and can only be exposed through empirical research that connect accumulations of subjective interpretation to conditions of capital. As a principle of orientation, habitus blends ideas and behaviour in the practical because the roots of both aspects are incorporated in us through language and socialisation. It also blends the material and the symbolic. In the case of the social use of communication technologies, the practices are guided by the merge of tools and tacit knowledge.

There is a close connection here to Anthony Giddens' structuration theory. Structuration is precisely a process that embodies a mediation between action and system without distinguishing between the two with separate "levels". Structure is the medium and outcome of action (Giddens 1984, 25). Bourdieu's combining of constructionist analysis and structuralism provides understanding of how the subject relates to material-cultural products, and how materiality mediates social relationships. Bourdieu has been more successful than many others to explore how social action involving objects is related to culture, and to demystify this empirically. It resembles structuration theory in that it seeks to combine structural and action theory into one approach where it becomes apparent that materiality plays an important mediating role. It may then be possible to avoid seeing technology as *either* neutral tools *or* total systems of technique. This is perhaps the major theoretical challenge of a sociology of communication technology.

Agency and the world of artefacts

The individual learns to apply principles of practice toward cultural products, on new areas. It acquires the competence to reproduce certain cultural principles and to apply them pragmatically in new contexts. Habitus also inspires subjective probabilities that give aspirations and prospects toward social hierarchies. For instance, habitus provides the individual with classificatory schemes toward art and cultural artefacts. To a variable degree, artefacts have symbolic value. Habitus mediates differentiated appropriation of external facts. Accordingly, it provides systematically different interpretations of cultural artefacts.

Technology and materiality play a prominent part in the understanding of agency. Such a broad understanding of agency as a theoretical precondition presumes the inclusion of tools. Among other things, *agency not only refers to choices of tools but also to the tools themselves*. Material and social conditions of social life have constraining as well as enabling influences on the acting subject and on the recurrent day-to-day practices. Day-to-day practices increasingly imply routines involving technologies and materiality. Technology-mediated action therefore, implies an inherent (but not ontological) connection between the actor and the tool. The choice of a different tool implies what aims she intends to realise. The 'choice' of different tools implies that the agent acts differently, a completely different form of conduct. Subjectivity and tool negotiate each other in the constitution of agency.

As one dimension of the mediation of communication then, *the tool is medium and outcome of technology-mediated action*. This means that the subject and the tool should be distinguished ontologically, but seen as an analytical totality. They inherently condition and affect each other in the course of daily life conduct. Material means and capability/intentionality prescribe each other mutually. As emphasised, for example to send a telegram, fax or electronic mail to my colleague cannot be considered as the same practice, merely involving alternative means. *The acting subject does not choose between means but between actions*. The tools are an inherent part of the particular action, hence, of agency. The tool 'suggests' its contextual availability to the subject. This point is often forgotten, precisely because the technology itself 'withdraws' from our attention.

However, this does not mean that the notion of the subject in technology-mediated action can be left out. The subject makes pragmatic choices according to social rules, that cannot be reduced to the power of the tool or of technological systems. Therefore the ontological distinction between the human subject and the material tool cannot be wiped out. But, neither can the tool be reduced to its everyday sense as neutral assistance, leaving the subject in complete power of singular practices. To understand everyday action, one must address the merging powers of subject, tool and context in the flow of practical everyday conduct. Only in this way (human) subjectivism and (material) objectivism can be transcended.

The distinction between tools and action is important for several reasons. First, the actor has the choice of applying technical means or to ignore them. Giddens' ontological notion of the actor's ability to make a difference for example, implies that the actor can principally abstain from technology-mediated action, though this is often impossible in modern daily life. Second, the actor may choose between different means of interaction, such as the letter, the telephone, the train etc. It is not suggested here that the identical message can be transmitted through several media. In this respect, McLuhan's famous credo about the media and the message is quite accurate. However, in most cases, it is not vital to the sender (or the receiver) to transmit the message in an exact form, but to get the message, in a pragmatic sense, across. The medium is not the message from the point of view of the sender, because the *intention* of a message can be delivered through different media. To emphasise the analytical distinction between tools and actions means to highlight the degrees of freedom that potentially are at the disposal.

C) Objectivation of knowledge

In a discussion of the interrelationship of action and hypertext as object/tool, the problem of objectivation cannot be avoided. In technological theory, the problem of objectification (or externalisation) is usually addressed as a large-scale, cultural process, and rarely in contrast to agency. Here, I shall stick to the individual problem of objectivation of habitus, of the vital recourse of agency called tacit or implicit knowledge.

The Wittgenstein of Philosophic Investigations (PI) turns away from his attempts to account for the formal structures of language in order to investigate its use (Wittgenstein 1978). Subsequently, he concludes that the users/subjects are central determinants of language. Language as an analytic tool for experience depends on language-in-use, the practical everyday use of it (PI, p 30). A central concept in PI is *language games,* although it is never clearly defined (PI, pp 7, 71). However, it becomes clear that it is the language-in-use of social interaction.

Inspired by Wittgenstein, Michael Polanyi elaborates the concept of tacit knowing. This is individual knowledge that cannot readily be accounted for through language. To use one of Wittgenstein's examples; most of us know what the clarinet sounds like, but it is almost impossible to explain (Wittgenstein 1978, 78). Polanyi's argument is that not all knowledge is formal knowledge, that it can not be isolated from its context and that formal knowledge can account fully for all aspects of practices. Non-verbal competence and knowledge are aspects of all personal knowledge (Kirkebøen 1993,363). This insight appears in various understandings of the life world, in Bourdieu's concept of Habitus and in Giddens' theory of agency in structuration.

A central problem here is whether individual competencies (i.e. tacit knowledge, habitus) become narrowed, specified and included into technology and the world of objects, and thus becomes what we normally label information. Tradition seems increasingly relieved and detached from its educating and normative role. In earlier times, one learned how to swing the axe by one's father. Today, the computer itself instructs in detail how it should be used. Important aspects of the cultural task of socialisation related to technology in everyday life, are transferred to the technology and materiality itself. Human competence becomes marginalised by technology and materiality. This thesis is suggested by Tom Johansen (1992) and I will discuss the relationship of knowledge and tools considering his arguments.

Does the displacement of rules into technology mean that tacit knowledge loses its significance in learning and application processes? What is left of personal competence when technology emerges as its own cultural mediator? For instance, the ideal of starting to use a computer with modem and a communication software for the first time without hands-on instruction, may in fact suggest that technology, step by step, takes the power over central aspects of agency. Clearly, for the user this means fewer frustrations. "Everyone" can take advanced technology into use, irrespective of prior competence. The seamy side of this is that the user apparently looses the possibility to act from personal informal knowledge.

If tacit knowledge must be acquired through inter-personal learning, through learning by watching and doing, and not through theoretical knowledge, one would expect tacit knowledge to become of marginal significance. Tom Johansen argues that tacit knowledge (implisitt kunnskap) dries out and with it, the relational understanding it provides. As materiality and technology increasingly take care of their own implementation and use, action of this sort becomes independent from context and tradition. Technification of everyday life implies increasing redundancy of tacit knowledge:

> "Det å omforme en stein til et graveredskap betyr egentlig at man bygger noen av de reglene som ellers må gis av de erfarne individene inn i redskapet selv, *slik at bruken gir seg mer automatisk av gjenstanden*. I løpet av redskapsutviklingen har man derfor skrittvis flyttet flere og flere av de tidligere sosiale direktivene inn i selve redskapet. Man har bygd bruksmåten inn i redskapet. Mens steinøksa tillater et mangfold av bruksmåter, tillater den elektroniske skjærebrenneren kun en. Redskapsutviklingen betyr at spesialiseringsfunksjonene mer og mer flyttes over fra den erfarne arbeidshånd til redskapet selv. Man bygger kunnskap og informasjon inn i maskiner og materielle prosesser. Redskapsutviklingens logikk blir da slik: Det som i dag er sosiale direktiv om bruk, er konkret redskap i morgen." (Johansen 1992, 117)

This implies that the significance of tradition for everyday mediated practices becomes subordinate. Instead, what increasingly dominates daily life is specialised expert knowledge. As a consequence, daily conduct becomes increasingly dependent on objective technology and materiality at the expense of subjective flexibility and direct social interaction. In short; technology colonises personal competence – systems-technical integration substitutes for social integration.

> "Det består videre i et bestemt forhold mellom *bruksreglenes beskaffenhet og deres sosiale overførings- eller innlæringsform*. Gjennom redskapenes

> konkretisering og praksisformenes oppdeling er det mulig å slutte at den sosiale formidling også kan skifte karakter fra å være av *retningslinjekarakter, eller prinsippkarakter,* dvs. en slags ferdighetsorienterende *standard* man selv må anvende etter beste skjønn i den konkrete praksissituasjon, til å bli av kontant *bruksanvisningskarakter*. Vil du gjøre det eller det, bruk redskapet slik eller slik. Realiseringen av handlingen minner da om bruksanvisningen, eller det vi vanligvis kaller å følge en teknisk regel." (Johansen 1992, 118)

Quite correctly, Johansen writes that:

> "Enhver formelt erhvervet kunnskap forutsetter som sin bakgrunn en krans av implisitt kunnskap ('tacit knowledge', eller uformelt erhvervet kunnskap, om man vil). Den erhverves gjennom å kjenne sin kultur rent *generelt* og dessuten kunne utføre de mer *spesialiserte* gjøremål den avkrever." (Johansen, 1992, 119)

He then goes on:

> "Mitt poeng med redskapsutviklingen er at det er dette som påvirkes: Man reduserer systematisk mengden av implisitt kunnskap ved å bygge den inn i materiellet selv, nettopp for å forenkle/tydeliggjøre overføringen. Det har det resultat at redskaper – og som sitt endepunkt maskinen – skal kunne brukes av 'ukyndige' etter en kort innføring og en nærmest påpekende demonstrasjon." (Johansen 1992, 120)

Johansen differs between *technically mediated* and *habitus-mediated action,* implying that the first mediates action in a narrow, technical way, whereas habitus mediates action through tradition, context and the understanding of the agent (Johansen 1992, 121). The first separates meaning from use through objectivation and reduces the agent to just another means. In contrast, habitus, as shown in the discussion above, mediates culture and tradition internally through personal competence. The first mediates formally, the latter through meaning. Both types mediate culture; the first through materiality, the second through the agent.

> "Idet materialiseringen representerte bevisst forsøk på å bygge bruksreglene inn i materiellet selv, betyr det at bruken i stor grad blir gjort *uavhengig* av tradisjonsforståelse og tradisjonssammenhenger. Den isolerer enkelthandlingen fra sin totale brukssammenheng på en helt annen måte enn eventuelt sosialt- eller habitus-formidlede handlinger. Der inngår handlingene uansett i en (mer eller mindre) forstått sammenheng. En økende teknifisering av hverdagslivet blir da lett synonymt med en redusert implisitt kunnskap. Enkelthandlingene behøver ikke lenger forholde seg til slike sammenhenger, og dermed heller ikke til det kulturelle fundament i samfunnslivet." (Johansen 1992, 121)

According to Johansen's understanding of the term, habitus provides the possibility to organise reality through practices according to cultural norms about right and wrong, honour, integrity, etc. However, it should not be conceived as merely action according to cultural norms and values in an Durkheimian sense. It is essential to the logic of Johansen's objectivation theory that habitus provides the capacity to act differently in different situations and to carefully supersede what is normatively defined. Indeed, from my reading, it seems that the point of creativity and improvisation is more explicit in Johansen's than Bourdieu's discussion, the latter being frequently accused of relying too much on structuralism.[2] Involving creativity as much as conformity, Habitus is a principle for handling uncertainty and for interpreting ambiguous contexts. It is the everyday art of applying flexibility from situation to situation. It involves mental understanding and common sense, if not the reflexivity to formulate the choices adequately.

Johansen's argument is that the reproduction of culture has step by step moved from internal to external mediation, from mediation through habitus to mediation through materiality. Johansen turns away from the Weberian categorisation of action orientations and rationalities, to focus on the transitory *nature of mediation of action,* and the subsequent historical change from human to material mediation. Habitus becomes increasingly irrelevant for a number of everyday life situations in a society textured by technology. For instance, to drive a car through the city involves that one follows a wide range of formal rules in a very detailed fashion. From the fact of technological society, Johansen concludes that tacit knowledge, inherent in the principle of habitus, renders increasingly obsolete.

Technical civilisation involves the use of things in most activities. "Material structure", according to Johansen, is the sum of external forces in action when artefacts are taken into use. Johansen assumes that all forms of action and interaction (samkvem) that somehow apply materiality, must somehow relate to this material in the same practical/technical way, irrespective of whether the action is religious, ritual, work, etc. This, in contrast to all forms of action that are not mediated by materiality, irrespective of context, purpose and social sphere. Johansen thus develops a fundamental distinction between materially and textually mediated practices – those which are mediated externally through materiality, and those that are mediated internally through habitus and tradition. Action is guided by the material structure or by the cultural arsenal. The development of materially mediated action means increasingly closed rules for the user, and narrow material "tracks" for later generations of users/agents.

Johansen suggests that this leads to an increasing technical understanding at the expense of a cultural understanding of the world. He seems all too easily to equate technology-mediated action and technical understanding. The vast artificial and technological landscape in modern society indicates to Johansen that technical understanding or technical rationality dominates everyday life:

> "En av den moderne kulturs særtrekk er at den tekniske forståelsen og den tekniske handlingsmåten eser inn i alle dagliglivets avkroker. Det fins snart ikke den periferi av samfunnslivet som ikke er brolagt med apparater, maskiner og elektriske innretninger. Alt dette er fortettet i uttrykket vår tekniske hverdag." (Johansen, 1992)

Johansen also holds that everyday knowledge incorporates the instrumental-analytic attitude of science, for instance by reducing problems to its singular elements or by functional division of labour (Johansen 1992, 104). This is one of the ways science legitimates itself. This also implies that everyday lives adapt an asymmetric and controlling attitude towards nature and increasingly towards other humans, as evident in the expert–client relationship. Whether everyday knowledge structures actually become in some sense scientific, cannot without implications be reduced to an empirical question because it means application of science to evaluate "itself".

However, Johansen cannot explain why we do not act like scientific operators or "replicants" in everyday life. It seems as if Johansen confuses technification and materialisation in everyday life with scientific rationality.

Alternatively, I hold that in everyday life, precisely due to our tacit competence, science disappears in technology. I do not necessarily refute that technologies are application or objectification of science (although the reverse is as much the case), that technology is what Marx called "frozen science", nor to address the (naive) claim that two different projects are pursued; that science is directed toward truth and technology toward efficiency. However, from the perspective of the user, only the technology (or rather; its tool dimension) is visible. Science becomes objectified in everyday technology. Science 'hides' itself in the guise of tools and through this, *opens itself for tacit knowledge in day-to-day practices*. This is why science in the form of scientific reasoning is peripheral in day-to-day life. That modern everyday life is increasingly influenced by scientific knowledge, (such as medicine and psychology in child care, economics in our personal economic management, knowledge about nutrition in our cooking, etc.), does not imply entirely scientification and colonisation of everyday knowledge mediated by scientific rationality. On the contrary, in social life, people receive and apply such knowledge in a tacit, non-scientific way.

What remains is the tacit resources of everyday life that produce non-technical understanding, and in fact do so by *drawing upon science and modern artificiality*. Johansen cannot account for the translation of scientific and technical knowledge into practical common sense of the life world. One reason for this confusion is that Johansen develops a theory of technology and materiality in everyday life without any ontological concept of interpretation in our 'lifeworld'. He believes that formal/objectivated knowledge is complementary to tacit knowledge, while the two forms in fact precondition each other.

Materially mediated action takes place in *and through* materiality and technology. This means that the use of tools or the living in materiality can only be understood through an encompassing concept of agency that includes various forms of knowledge and the materiality involved. To drive a car through heavy traffic or to operate a computer requires as much habitus and tacit knowledge as the use of the stone axe once did. Technology-mediated action prescribes as much tacit or implicit understanding as other forms of action in everyday life. Advanced technology cannot be used exclusively through external instructions. Throughout history, habitus and tacit knowledge has been in a process of continuing transformation according to new environments. However, with the transformation toward advanced modernity, habitus provides resources for how to go on in everyday life as much as in pre-modern times and cultures. In fact, what Johansen calls strategic rules resemble precisely habitus in a technological environment.

The process of objectivation of knowledge should be reformulated to a problem of objectivation of culture. What is taking place is that relatively specific 'knowledge' in the intersubjective cultural world is incorporated into materiality and culture. One may distinguish between two processes: a) the professionalisation of general cultural knowledge to expert knowledge, and b) the individualisation and materialisation of professional knowledge to 'self-service' knowledge (Gershuny & Miløs 1983). This means that the objectivation of knowledge – which is what we simply call information – is normally paralleled by personal, tacit knowledge of how to orient and handle the materiality. The most important case is alphabetisation: With the explosion of objectivation of knowledge into information as typed text since the late 15th century, a general increase of the competence to read and write has followed. Johansen fails to distinguish between objective cultural knowledge as information and personal, tacit knowledge. When the first kind becomes increasingly objectified the latter kind automatically follows in Johansen's scheme, causing unfortunate reductionism.

The dilemma between implicit knowledge and materially mediated action as formulated by Johansen is therefore misconstrued. In traditional society, there were good or bad tailors and locksmiths. Both their efficiency and their artistic performances varied. Today, there are good and bad programmers and car drivers. In a technologically advanced society, the problem of competence is just as relevant as then. There is still a question of using technological tools with reasonable flexibility and competence, just as it is still a question of acting with reasonable flexibility in material contexts.

Generally, to distinguish between materially mediated action and habitus irrespective of use or context does not uncover the varying challenges technology and materiality constitute for the modern individual. It does not account for how individuals go on in a highly technological society. Neither does it account for how habitus is reproduced through technology in modern society. Johansen's rejection of Weber's differentiation of rationality types leads him to distinguish between two forms of rationality; technological and non-technological rationality. This unfortunate reduction of the role of materiality and technology leads to unjustified technological determinism, since there appears to be only one way of using technology; following Johansen, society will increasingly act according to distinct technological rules. A technological society can only proceed according to the formal and reductionist rules and preferences inherent in its technology. Hypertext and similar media, according to this view, lead to an emptying of personal competence – irrespective of the quality or nature of the media. Alternatively, I hold that we must keep tacit knowledge separate from information, that tacit knowledge is a *necessary requirement* for handling technology in everyday life, and that tacit knowledge changes along with new and increasing technology in daily life.

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[2] *According to Sewell, for instance, Bourdieu ends in a combined (ideal and material) determinism which makes significant change seem impossible. The concept of habitus is too totalised and unified as it encompasses all aspects of social experience, and thus cannot account for change deriving from within, from habitus itself (Sewell 1992,15–16). de Certeau claims that Bourdieu is biased in emphasising the adaptation of the individual to the strategies of dominant structures (de Certeau 1984, 59–60). Miller holds that Bourdieu too easily reduces consumption patterns to expressions of class divisions. Bourdieu tends to fall back on an economist model where social hierarchy is an effect of economic or symbolic capital (Miller 1987, 155).*

Practical action and the 'art of using'

Maurice Merleau-Ponty notes that life-world perception competently gears the body through the world of artefacts. The perceptual awareness he describes here is precisely tacit knowledge inherent in practical conduct:

> "A woman may, without any calculation, keep a safe distance between the feather in her hat and things which might break it off. She feels where the feather is just as we feel where our hand is. If I am in the habit of driving a car, I enter a narrow opening and see that I can "get through" without comparing the width of the opening with that of the wings, just as I go through a doorway without checking the width of the doorway against that of my body." (M. Merleau-Ponty: Phenomenology of perception 1962, 52–53, quoted in Ihde 1990, 38.)

It is impossible to understand technology-mediated action in everyday life without seeing it in relation to tacit knowledge. Tacit knowledge is informed by both expert knowledge necessary to master new communication technologies, and by the implicit intention, such as to transmit a message, to communicate with others, to entertain oneself, etc. Tacit knowledge fuels and reproduces the meaningfulness of technology-mediated action and thus is a complete part of it.

Success for communication technologies in everyday life implies that they become mundane and "trivial" instruments embedded in the flow of everyday practices. The "easiness" of computer technology in everyday life is really a question of whether the technology can be adequately translated to the level of tacit knowledge. The private telephone, for instance, appears as an undisputed success, while computer-mediated communication is associated with more technical trouble. Tacit knowledge is a vital aspect relating the subject to her socio-material environment. 'Easiness' means wider "space" for subjective intentions. Tacit knowledge is guided by common sense, "between" automatic and calculated action, and by social rules integrated with technological tools. When we say that a computer is more or less "easy to use", *we really refer to the tacit correspondence of the rules and recourses of the technology, and tacit knowledge inherent in practical action.* Intersubjectively produced common sense cannot be substituted by user manuals and instruction courses. Technology-mediated action can only be produced through meaningful and practical application of tools and the non-discursive reproduction of mutual knowledge that come close to routines and procedures in everyday life. Only then, communication technology seizes its alien character as simply materiality and becomes translated into *tools*. In this light, the task for hermeneutic social science is, for instance in the case of hypertext, to investigate the technical and contextual conditions for this translation.

Practical action, then, does not emerge from pre-programmed responses, nor from subtle reflections. Tacit knowledge is inherent in the practicality of daily action itself. Communication technologies are part of the action they mediate through the rules and recourses of their symbolic and material character. Let me give one example. If I want to communicate to my mother while I am at home, I do not bracket this down to: 1) communicate to my mother and 2) different options available for doing so (write a letter, take the bus to her home, make a phone call, etc.). Rather, the decision is communication-through-telephone, communication-through-letter or communication-face-to-face, and so on, which are quite different experiences, for both parts. *The intended communicative process and the technical means for accomplishing it therefore, are inseparable in a practical context.* The choices and use of communication technologies define the particularities of mediation with its distinct communicative characteristics (spoken, written or typed words, monological or dialogical feasibility, etc.). Thus, communication-technological mediation is the medium and outcome, of all aspects of technology-mediated action. Therefore it is irrelevant to distinguish too sharply between the use of terminals (giving commands, dialling, etc.) and the distanciated process of mediation. Technology-mediated action reproduces mediation both through manual and linguistic operations. Both are inherent in technology-mediated action as agency.

Rather than comparing and contrasting tacit knowledge and objectified knowledge, the challenge is to understand what human, moral, knowledgeable (individual and collective) agents do with their tool-systems and with their objectified knowledge, giving various unrecognised consequences. In other words, tacit and objectified forms of knowledge are not complementary but preconditioning in various compositions and contexts. Practical actions are always necessary in the wrestling with the new objectified contexts and mediators of social relations. In a technology-textured society, the question is not how objectified knowledge excludes tacit knowledge, but how they modify each other into technology-mediated agency. Lundequist summarises this aptly:

> "Som motsats till den subjektiva kunskapen kan man ställa den "objektiva kunskapen", som främst Popper har definierat som kunskap *utan kunnande* subjekt. Den kunskap som en dator kan ha tilhör denna kategori. Begreppet "objektiv kunskap" refererar til människans säregna förmåga att "binda tiden" genom att lagra kunskap i museer, bibliotek, arkiv, i böcker, bandstationer, tidskrifter, skivor, bilder, etc. Den objektiva kunskapen är sådan kunskap som det går att representera med hjälp av täcken och symboler, som därefter lagras på ett medium av nogot slag – som bokstaver på papper, som spår i en grammofonskiva osv. Den objektiva kunskapen existerar som konkret realitet, även om den vid ett visst tillfälle inte är känd av någon specifik människa. Detta gör den objektiva kunskapen till en kunskap utan kunnande subjekt, en kunskap utan mänsklig bärare. Herbert Simons kunskapsteoretiska misstag är att han identifierar all kunskap med den objektiva kunskapen. *De två kunskapsformerna utesluter inte varandra, utan kompletterar och förutsätter varandra. Den objektiva kunskapen blir tillgänglig och användbar för oss endast via vår subjektiva kunskap: att t.ex. använda eller programmera en dator förutsätter stora mängder av tyst kunskap."* (Lundequist in Göranzon 1983, 77–78, last emphasis added.)

Tacit knowledge is the "invisible software" always at play in agency. Day-to-day life is composed by activities guided by relatively taken-for-granted assumptions, whether one carries traditions and routines further, or whether the activity involves creative impulses. Tacit knowledge is composed of daily competencies, confidence toward other humans and technology and experience. It is knowledge yet to be formalised or made explicit by for example science. To formalise knowledge in hypertext systems, for instance, does not mean that tacit knowledge becomes correspondingly reduced. Rather ironically, the 'critical' proponents of the objectivation of knowledge-thesis, which fear a reduction of personal tacit knowledge, tend to conceptionally reduce 'knowledge' to information. In so doing they join forces with 'Scientific Management', schools of behaviourism as well as a number of works on Artificial Intelligence which stand accused of reducing knowledge to formal knowledge, and agency to instrumental operations for the more or less explicit purpose of targeting and testing knowledge 'scientifically'.

To use communication technology implies both technical mastering and the relationship between the use process and the conventions of everyday life. Formal knowledge is not sufficient. One needs to know implicitly how the technology is interwoven in wider processes of meaning, the 'place' of the technology. To learn how to use technology is to learn about the world which the technology inhabits. Tacit knowledge includes a certain understanding of what we do when we use. The articulated part of the required knowledge is only the tip of the iceberg. [3]

As a field of play, a framework of activity, communication technology is only partly in the hands of the systems that created its technical facilities (Feenberg 1991, 88). In spite of user manuals, commands and instructions, it can never define its own use completely. Communication technology escapes partly the totality of technocratic logic and opens itself to differentiated and undetermined practices. Andrew Feenberg writes:

> "To the extent that this logic has not been perfectly anticipated and mastered – and it never can be – there will be breakdowns, irrationalities or imperfections in the order of the plan. The 'weaker players', those whose lives or work are structured by the technical mediations selected by management, are constantly solicited to operate in this range of unpredictable effects. The coincidence of sociogram and technogram is therefore never absolute. As a result, tactical responsiveness is not something important into the technically mediated game from the outside ('life', 'instincts', etc.), but is a form of socially necessary freedom generated immanently within the game itself." (Feenberg 1991, 88–89)

Contrary to the argument that advanced technology implies a sort of necessary Taylorism contradicts their flexible and dynamic potential. Rather that being based upon inherent, rigid controls as in the case of mechanic technology, computer technology employs a wide range of electronic commands separated from the machine itself. This allows for an unprecedented flexibility in selecting goals and for the ways to reach them. In other words, it increases the role of the mind, skill and will of the agent. Technical design permits this in order to make both technology and labour more flexible in a rapidly changing production life. The flexible adaptations of technology are supported by its communicative dimension that may give work a learning dimension which blurs the distinction of mental and manual labour, of education and work (see Hirschorn in Feenberg 1991, 94, Feenberg 1991, 95). In fact, in production life as well as in everyday life, automation that extends the function of the machine and reduces choices of the agent may simply be irrational even from an instrumental and productivist perspective. Rather than subscribing to the 'objectivation' thesis presented above, I propose that communication technology is located in a sphere of competing perspectives. The following statement by Hirschorn is as much relevant for consumption, as for production technologies:

> "The principle of integration and utopian design reinforces a Taylorist view: the more perfect the machine, the simpler and more rational the job. Systems theory, control engineering, utopian thinking, and Taylorist prescriptions all converge to limit the workers' skill. In contrast, the principle of flexibility creates a conception of work in which the worker's capacity to learn, to adapt, and to regulate the evolving controls becomes central to the machine systems' developmental potential." (Hirschorn in Feenberg 1991, 96)

Communication technologies as hypertext are ambivalent technologies available for a plurality of alternative developments (Feenberg 1991, 96). Software, design and language embody assumptions that can either invite or extinguish human skills and involvement. Besides the argument that communication supports flexibility, there is an argument related to context: In everyday life, and in domestic contexts in particular, the space of autonomous manoeuvres are larger than in working life. In the household, most aspects of activity (context, leadership structure, goals, motivation), are less formal and explicit. The hidden cultural agenda of communication technology can only marginally be detected in the technical design.

Insofar as agency and habitus contain formal knowledge and that habitus is differentially reproduced, however, makes it plausible that technical integration creates new social problems of inequality. Habitus may prove insufficient for the mastery of communication technology for some social groups. However, this regards the formal stock of knowledge. Further, it is related to that computers and advanced communication technologies are associated with certain (highly educated) segments, reproducing images of a technology reserved for some groups.

That technology is socially constructed in the production as well as in the use process means that social and cultural (symbolic, mental) force makes communication technology into what it is to us. Further, technological development and growing complexity implies that technology is increasingly culturally constructed and subsequently less defined by the techniques 'itself'. This is not to say that tacit knowledge or habitus in general become gradually transferred from culture to techniques. It means that one needs cultural supported competence to recognise the purpose, reason, relevance and applicability of technology. It is probably easier for a complete stranger (due to the current state of globalisation, we probably would need an alien from outer space) to guess what an axe can be used for than a telephone or a computer. Little is given from the techniques itself, because of its growing 'closeness'. With the case of the computer, it is not at all clear where or how the technology meets its environment (natural or social) as it is with the blade of the axe. And naturally, this cultural competence, the habitus, is socially differentiated in a society of inequality.

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[3] *Göranzon and his colleagues at the Center for Working Life (Arbetslivcentrum) in Stockholm report a number of cases from Swedish working life involving computers whose work heavily depends on knowledge that cannot be formulated explicitly in manuals and text-books (Göranzon 1983, 25).*

Conclusions

According to Bolter (1991), we live in the late age of print – a diagnosis I do not subscribe to. However, it is clear that new forms of writing and reading emerge, hypertext being only one case. This paper started from the assumption that we must modify our conception of 'reading' in relation to hypertext and similar forms to a hermeneutical (interpretive) notion of agency or action.

Since I wanted to clarify the tool aspect and perceptual mediation, the paper attempted to clarify some central aspects of the term 'technology-mediated action'. First, technology-mediated action was culturally specified (and distinguished from the usual mass media) by relating it to tools and perceptual mediation. Second, technology-mediated action was connected to the acting subject through the notion of agency.

One central problem in the interrelationship between action and tool was discussed; the thesis of objectivation of habitus. As an alternative position, I argued that tacit knowledge and habitus live on in a highly technical integrated society as in previous phases of history. While formal knowledge is increasingly implemented into technology, tacit knowledge always transforms itself according to new technological environments. The problem is not the tacit knowledge required to handle advanced technology, but the symbolic character of such technology that may exclude it from groups with less symbolic, cultural or economic capital. Advanced communication technology, such as hypertext, is ambivalently located in a contested terrain of multiple definitions, contexts and interpretations, where it may follow roads leading to both autonomy and control.

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Information exchange in MultiTorg

BY DAG SOLVOLL, GEIR IVARSØY, HÅKON W LIE, AND PER E DYBVIK

654.1:681.3

1 Introduction

The creation of national and global information highways is being discussed in many fora. There are, however, a number of problems that have to be solved before a world-wide information network will offer the required quality of service.

This paper discusses problems and options when exchanging information in heterogeneous networks. The basis of the discussion is the everlasting "Tower of Babel" problem; to exchange information, one needs a common language. Similarly, when computers communicate, they too need a common basis for the exchange of information. Establishing common formats between applications is one of the major challenges in order to promote communication.

Section 2 discusses the relationship between information formats and the internal information structure used by applications.

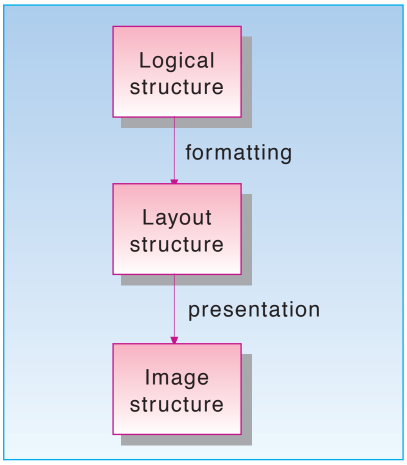


Figure 1 The formatting and presentation process

Section 3 discusses some of the emerging document formats in distributed multimedia applications.

Section 4 contains a description of an information system set up as a part of the MultiTorg project at Norwegian Telecom Research (NTR). We describe some of the options when setting up a distributed information system in a heterogeneous environment, and the resulting system.

Finally, the paper ends with some concluding remarks about the future for MultiTorg and information systems in general.

2 Information models; structure and distribution

When writing a book, the author structures the text in logical parts, e.g. chapters; when making a movie, the director structures the film into scenes. In order to represent these human created structures in a digital computer, the computer needs data structures. These data structures are described using abstract grammars, and represented using specific formats, either for computer storage or as transmission formats.

2.1 Information structures and formats

Every system contains both structure and process. The process changes the structure and the structure represents the state of the system. In a computer application the structure is represented internally as a data structure and externally as a data format. In order to exchange information, the internal data structure has to be written into the external format.

A document is a piece of information that can be processed as one unit. Examples of documents are business reports, invoices, movies and newspapers. A document might be described using several structures, but we can distinguish between two main types; structures regarding the whole document, and structures regarding a particular content type, e.g. graphics, text, or audio. The types are denoted document structures – and content structures.

Different document structures denote different views of the document. Reading an office document, the user may see the "logical" structure defining the chapters, sections and paragraphs, or the "layout" structure defining pages, columns and blocks.

Formatting is the process of transforming the logical structure into a layout structure. Presentation is the process of transforming the layout structure to an image structure, e.g. a bitmap image on a screen or printer. See figure 1.

In order to communicate, the internal document structure needs an external representation, called a document format. To describe this format it is necessary to use both an abstract syntax of the format, e.g. defined using BNF, and the coded representation of this syntax.

Figure 2 shows a sample document structure description (a), and the coded representation (b) described, using an ad hoc BNF. (c) contains a sample document using the grammar, and coding of a and b.

```
Article      ::= <article> (Paragraph |
                 Picture)* </article>
Paragraph    ::= <para> <TEXT>
                 </para>
Picture      ::= <figure> <BITMAP>
                 Paragraph </figure>

<TEXT>       ::= ASCII string
<BITMAP>     ::= OCTET string
```

Figure 2a An abstract syntax of a sample document structure

```
<article>      ::= ASCII-CHARS
                   ( '<' 'a' 'r' 't' 'i' 'c' 'l' 'e' '>' )
</article>     ::= ASCII-CHARS
                   ( '<' '|' 'a' 'r' 't' 'i' 'c' 'l' 'e' '>' )
. . .
ASCII string   ::=/* All ascii characters */
OCTET string   ::=/* a string of 8-bit bytes */
```

Figure 2b The coding of the abstract syntax

```
<article>
    <para>
        This is a sample of some paragraphs. This
        is the first
    </para>
    <para>
        And this is the second.
    </para>
    <figure>
        ...................
        ...................
        <para>
        Figure 1. And here is the figure of the arti-
        cle
        </para>
    </figure>
</article>
```

Figure 2c This is a sample document using the abstract syntax and coding in Xa and Xb

Figure 2 shows a sample document structure description (a) and the coded representation described (b) using ad hoc BNF. (c) contain a sample document using the grammar, and coding of a and b

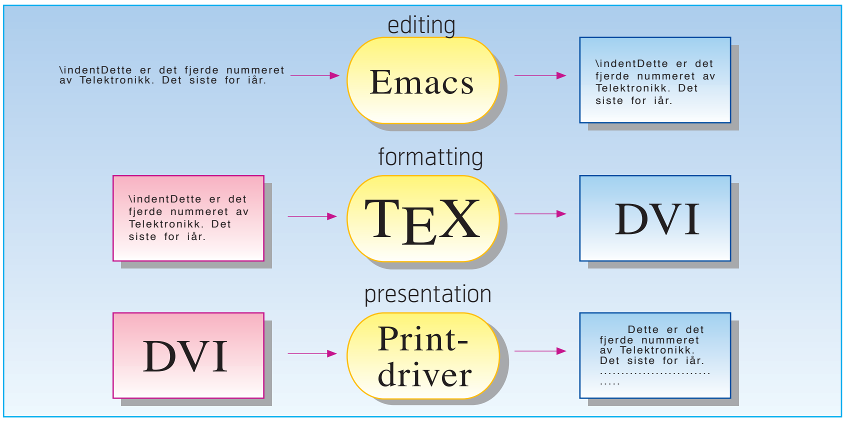


Figure 3 The three document processing stages of TeX; editing, formatting, and presentation

Many applications operate with several structures simultaneously. FrameMaker, a desktop publishing system, uses a logical structure including paragraphs, pictures, tables, and maths. Also, FrameMaker uses style-sheets to indicate the formatting of each paragraph. Layout processing produces a layout structure from the logical structure and the style-sheets, which is imaged onto the physical screen or printer, which is the final structure.

The TeX system is another example; the user creates the document using the abstract TeX grammar and a conventional text editor, e.g. emacs. The document is then formatted by the TeX formatter creating a layout format (DVI), which can be presented as a bitmap on the screen or on a printer (see figure 3).

The content of a document might be of several types; text, bitmap, video, etc. Each content type has its own structure and format. For example text has a format containing character codes and sets, fonts and other characteristics associated with text.

The structural elements of a bitmap, on the other hand, are called picture elements (pixels). Compression techniques, which are quite common, are also parts of a bitmap structure.

2.2 Translation among document formats

Exchanging documents among heterogeneous applications requires translation. Translation is the operation of transforming a document in format A into the same document in format B. If the two *formats* A and B are different but derived from the same structure, the translation is easy. This is the case in many document formats based on a logical mark-up language. In such documents the text is interspersed with tags (mark-ups) determining a structured element (figure 2(c) shows a sample of a logical mark-up document). So, when the structure in A and B is similar, and only the tags differ, the translation process is trivial.

If both format and structure of A and B differ, the translation process becomes difficult, sometimes even impossible. Translation from layout structure (e.g. a Postscript document) to a logical structure (e.g. LaTeX) is in general impossible. The translation has to be performed on similar structures, i.e. logical to logical, or layout to layout.

For a description of some of the translation utilities we have developed in Multi-Torg, see section 4.

2.3 Hyperdocuments

References are essential in documents. Both footnotes and pointers to other documents are commonly found in paper-based documents. In electronic documents, hypertext implements references and lowers the threshold of accessing the referenced information to a mouse click.

In the 80s, hypertext systems typically referenced themselves in closed loops. With the emerging global computer networks, hyperlinks will offer access to documents outside your disk or LAN, and they are still only a mouse click away.

Documents on paper can be retraced due to referencing conventions and numbering schemes like ISBN, which provides a unique identity. Using this system, the source of the referenced document is uniquely determined. Electronic documents need similar functionality, and one emerging option is the Universal Resource Locator discussed in 3.2.2.

3 Standardisation of document architectures

In order to communicate information in a heterogeneous world it is necessary to have a standardised interchange format. The simplest – and most widely used – is ASCII, which is useful for unformatted text but cannot represent document structures.

Page Description Languages, e.g. Postscript, take another approach to document interchange. They allow you to exchange electronic documents preserving layout information, but the documents are not processable – you cannot edit the content of a document.

In order to handle the interchange of processable documents with various content types (text, bitmaps, audio speech, etc.) the standardisation organisations have developed standards like ODA and SGML. These will be described in the following sections.

There is also ongoing work to provide standards for the representation of documents with continuous content types like audio and video, and with hypermedia functionality. These are HyTime (based on SGML), MHEG, and several extensions to ODA.

3.1 ODA

The Open Document Architecture (ODA) is an ISO and CCITT standard designed to facilitate transmission of compound documents between open systems. It has its focus on blind interchange – the originator need not know anything about the recipient's system. An ODA document may easily be transferred from one word processor to another (if both support ODA). In this case the document is said to be in a "revisable" or "processable" form. ODA also supports a "final" or "formatted" form, i.e. the receiver cannot edit the document.

The ODA standard addresses the interchange of documents in a typical office environment. Examples of documents that can be handled are memoranda, letters, invoices, forms, and reports. Documents may include graphics and images. In order to meet the increasing interest in new data types, there is also ongoing work to add hypermedia functionality.

3.1.1 Description

The ODA standard divides information into three main categories: logical information, layout information, and content. Further, ODA also has three more components: generic structures, styles, and a document profile.

The logical information is the structuring of the content in terms of hierarchy and order. E.g. a chapter may be seen as a sequence of sections, which in turn may be a sequence of paragraphs. This is called the logical structure.

The layout information organises the physical appearance (size and positioning) of the content on a presentation medium (typically paper or computer screens). ODA defines a hierarchy of layout components called page sets, pages, frames and blocks. This organisation is called the layout structure.

Content is organised in portions of either text, images or graphics. These content portions are references from both the logical and layout structure, and make it possible to either have a logical view or a layout view of the content. Different views of the document facilitates different applications. A printing application would only need the layout view in order to construct an image of the document, while a word processor would use the logical view in the editing process. See figure 4.

Generic structures can be logical or layout. They are rules which define the class of a document. For example, a class "article" may determine that the document must start with an abstract, followed by one or more numbered chapters, each consisting of only one level of sections.

ODA has divided the style concept into layout styles and presentation styles. Layout styles are associated with the logical structure. They can specify, for example, that a heading and the following paragraph both should appear on the same page. Presentation styles are concerned with the layout and imaging aspects of the content and are specified for the lowest level logical and layout components. There are different sets of presentation styles for different content types. For character content one may specify parameters like line spacing or which fonts to use.

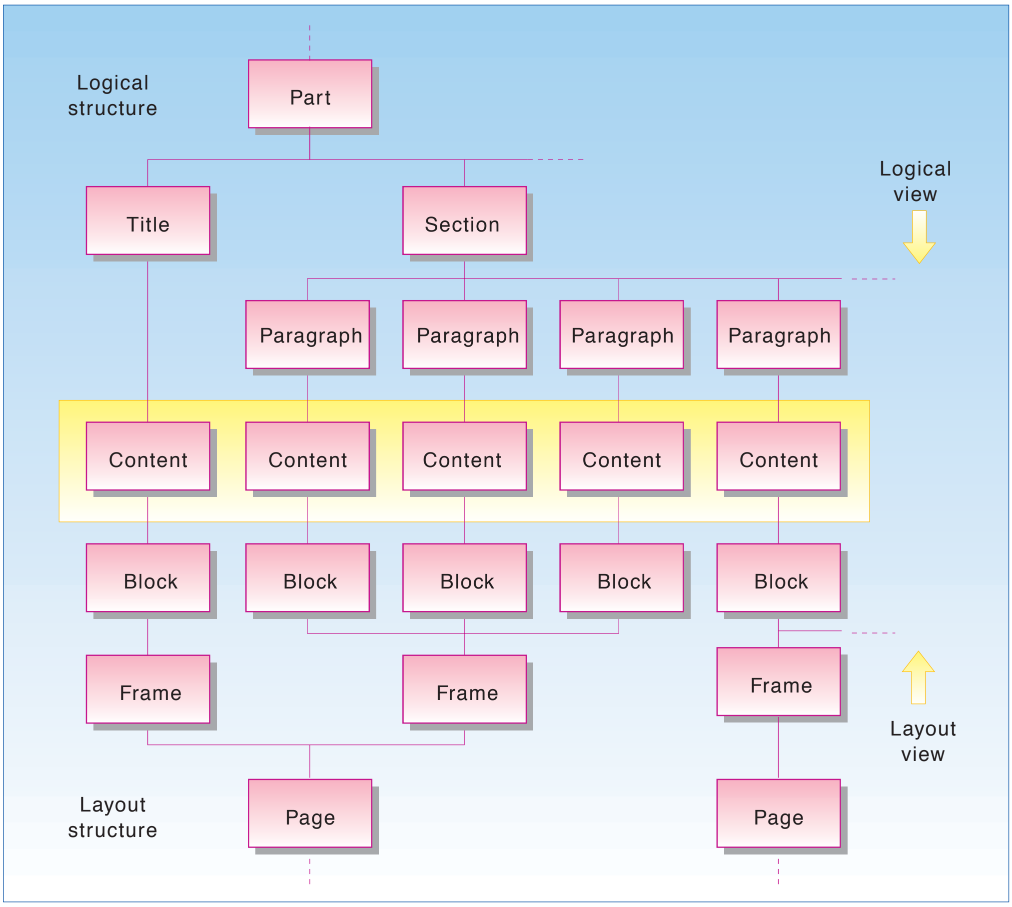


Figure 4 The layout and logical structure of ODA

The document profile contains information about the document as a whole. It has management information (e.g. title, name of the author, keywords), and technical information like which structures are present and which coding standards are used for different content types.

3.1.2 Document Application Profiles

ODA is a very complex standard because of its general applicability. However, it specifies a way to form subsets of the total set of features to implement different levels of user requirements. These subsets are called Document Application Profiles (DAP).

There exist three levels of profiles with increasing levels of features. The first level provides for documents containing character content only. The document may have sequences of paragraphs which are laid out in a single column of text. The second level profile supports documents with both character, image and graphics content and can be structured into chapters, sections, and paragraphs. The content may be laid out in multi-columns. The third level will provide support for more sophisticated word processing.

3.1.3 Extensions

The current version of ODA addresses documents in an office environment, but extensions to the standard are under way. Support for audio will be included in the next version of the standard, while the standardisation work on video has just begun.

Also, there is work going on to add support for hypermedia (HyperODA). In the HyperODA model, a document consists of one or more ODA documents containing links between arbitrary document elements. These links may be separated from the documents they refer to and interchanged independently.

Document source:

This is an example of a <A HREF="another_file.html"> hyperlink </A>

Figure 5a The start-tag <A> and end-tag </A> delimit the text, in this case the word "hyperlink", which is the beginning of the hyperlink. The "A" tag has the attribute "HREF" which gives the location of the end of the hyperlink, in this case the file "another_file.html"

Sample URL:

<A HREF="http://www.nta.no:80/demo/file/another_file.html">

hyperlink </A>

Figure 5b In this sample the protocol definition is 'http'; the host address is www.nta.no, the port number 80 which is default, and the file name/demo/file/another_file.html

3.2 SGML based standards

3.2.1 SGML

Standard Generalised Mark-up Language (SGML) is a language for defining structured documents and is an ISO standard. In contrast to ODA, SGML's primary concern is logical structuring of the content. The logical structuring is done by adding semantic mark-up to content parts.

Mark-up is text that is added to a document in order to convey semantic information. The mark-up serves two purposes: separating the logical elements of the document from the content, and specifying the processing function to be performed on those elements. The logical elements are marked by adding a generic identifier to the start of the element (start-tag) and to the end (end-tag).

It is possible to define classes of documents with a Document Type Definition (DTD). A DTD defines the mark-up structure permitted in the class. It is also used to minimise mark-up, i.e. permit omissions of unnecessary tags. Neither SGML itself nor the DTD specify how the document should be formatted – this is application dependent.

An SGML document is divided into three different parts. The first is the SGML declaration which specifies the character set of the document; which characters have a special meaning to SGML and which advanced features are used. The declaration can be omitted if the document only uses default features. The second part is the DTD which specifies the document type and which tags can be used. The last part is the marked-up document itself, called a document instance.

The lack of layout information in the document format has both advantages and disadvantages. The advantage is that a single SGML document can be formatted or processed in many ways. This makes SGML very powerful and general. The disadvantage is that in order to be used as an interchange format, the communicating parts must agree upon the interpretation of the used DTD.

3.2.2 HTML

Hypertext Mark-up Language (HTML) is defined in terms of SGML and is a simple SGML DTD. It is capable of handling hyperlinks and simple formatting. The hyperlinks are implemented as tags with attributes giving the location of the end of the link. This location can be within the document itself as well as an external document. Figure 5a gives an example of a hyperlink in an HTML document.

The structure of the hyperlink is defined by a mechanism called "Universal Resource Locator" (URL). This is in fact an address containing three sub-addresses; a protocol definition, a host address (IP-address) with port number and finally a file name. (Figure 5b contains a complete address.)

HTML is the format used in the World Wide Web (WWW) information system. WWW uses a client-server model, and the client is responsible for formatting and presenting HTML documents. Figure 6 shows an example of an SGML document using the HTML, For a description of WWW see section 4.7.

Because of the limits in the formatting capabilities in HTML, an extension of the format called HTML+ is under way. New features that will be added in HTML+ are support for tables, captioned pictures, and fill-in forms for querying remote databases.

3.2.3 HyTime

The Hypermedia/Time-based Structuring Language (HyTime) is a standardised infrastructure for the representation of integrated open hypermedia documents. It is based on SGML and defines constructs for making DTDs for hypermedia documents. HyTime can represent hypertext linking, time scheduling, and synchronisation. Links can be made both to documents that conform to HyTime and to other documents.

Objects in a HyTime hyperdocument can be formatted and unformatted documents, audio and video segments, still images, etc. The documents that constitute a HyTime hyperdocument can conform to any architecture and be represented in any notation permitted by that architecture.

HyTime is intended to be an interchange format for hypermedia applications and not used as an internal representation for such applications. It is highly expressive and may be difficult to optimise for runtime efficiency.

3.3 MHEG

MHEG is a draft standard for representing multimedia and hypermedia information objects, named after the ISO group developing it (Multimedia and Hypermedia information coding Expert Group). The standard does not define any content format, it only provides rules regarding the structuring of objects. MHEG accepts the use of any standard format for monomedia content.

MHEG categorises the objects in classes which share behaviour and characteristics. MHEG defines content classes for each relevant media type, a selection class for interaction, an action class for rendering objects, a link class for hyperlinks and a composite class for grouping related objects.

MHEG represents objects in a final form with the aim of direct presentation. It is thus unsuitable as an input format for hypermedia authoring applications. A potential approach is to use MHEG as the output format of hypermedia application taking HyTime as input. This would benefit from both the expressive power of HyTime and the runtime efficiency of MHEG.

```
<TITLE>ÅPEN LINJE nr 14</TITLE>
<IMG SRC="http://www.nta.no/fapen5.gif">
<H1>Teleslekt på is</H1>
TNM-prosjektet Teleslekt i Oslo er foreløpig lagt på is og de ansatte jobber nå for
Divisjon Nettleveranser. Flere TNM-prosjekter må nå utsettes fordi hovedvirk-
somheten trenger folk.
<AHREF="slekt.html">(Les mer ...)</A>
<H1>Frisk på jobben</H1>
Å ha det godt på jobben – både psykisk og fysisk – er en forutsetning for å gjøre
en god jobb. Nå er et såkalt friskvernopplegg på trappene – med Region Øst
som mulig prøveklut.
<A HREF="frisk.html">(Les mer ...)</A>
<P>
<IMG SRC="line.xbm">
<UL>
<LI> <B><A HREF="leder.html">Leder</A><B>
<LI> <B><A HREF="overskrifter.html">Overskrifter</A></B>
<LI> <B><A HREF="notiser.html">Notiser</A><B>
<LI> <B><A HREF="stilling.html">Ledige stillinger</A></B>
<LI> <B><A HREF="innlegg.html">Fra organisasjonene</A></B>
<LI> <B><A HREF="tormod.html">Debatt</A></B>
</UL>
```

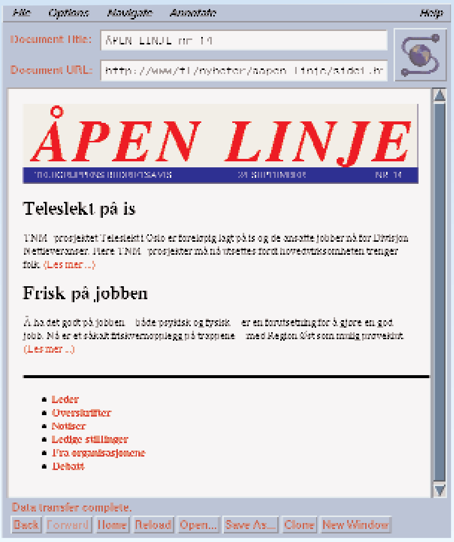


Figure 6 The figure (a) shows the presentation of the HTML source in (b). The client used in this sample is "Xmosaic" an X11 client from National Super-Computing Center (NCSA). The red coloured text in the presentation is the mark of the hyperlink in the document. Examining the source we see that from within this sample information, there are references – or hyperlinks – to other documents in the Internet world.

4 The MultiTorg project

At Norwegian Telecom Research, the MultiTorg project attempts to develop models for supporting a distributed, electronic marketplace for information. In this marketplace, information vendors will offer their electronic goods, and customers can choose from a variety of services and products.

The information marketplace includes three actors; information providers, network and marketplace operators, and finally the users (see figure 7). The marketplace will provide functions for both the information providers and the users. Examples of such functions are: communication protocols, marketing, translation among information formats, accounting, and security.

The MultiTorg project is not attempting to build a full-scale electronic market, rather, we are trying to build tools for demonstrating the potential of an electronic information marketplace. We have developed several prototypes serving different equipment and users.

One prototype is based on the World-Wide Web which is one of the fastest growing services on the Internet. Another prototype forwards personalised news and mail to pagers. In this paper, we will concentrate on describing our work within the context of WWW.

4.1 The World-Wide Web (WWW) model

In 1986, at the CERN particle physic laboratory, a group of people started working on something that now is referred to as World-Wide Web. The idea behind "the web" was to use the rapidly growing Internet infrastructure to distribute information in an efficient manner throughout a campus network; later also to the Internet.

The WWW is a client-server architecture where the server is the protector of information. There are many servers in the network (see figure 8) and clients access a server by an address definition called a "Universal Resource Locator" (URL).

Most software supporting the web is freely available. This includes servers as well as clients. At this point, all servers run under the UNIX operating system, taking advantage of native support for TCP/IP networking.

On the client side, implementations exist for X11, MS-Windows, text terminals, etc. If you have a WWW client, we welcome you to access one of our servers at http://www.nta.no/. From there, you can access most of the content described in section 4.2.

4.2 Information included in MultiTorg

The technology of WWW is general enough to be applied to many environments. With great success, various types of information has been made available using WWW, e.g. documentation, personnel databases, weather reports and news. We believe WWW is suited for commercial use; i.e. to mediate information between suppliers and consumers of information.

In order to gain experience with supporting information systems in heterogeneous environments, we gather information from various sources. The goal has been to offer information that is interesting enough for people to start using the system without other incentives. (See figure 9.)

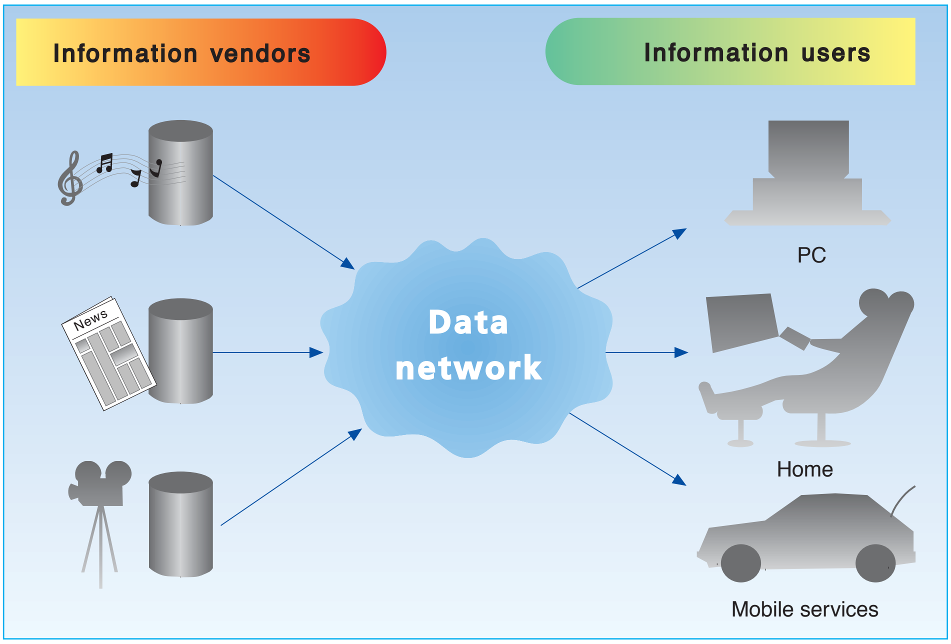


Figure 7 A model of the information market where information vendors meet the users on-line

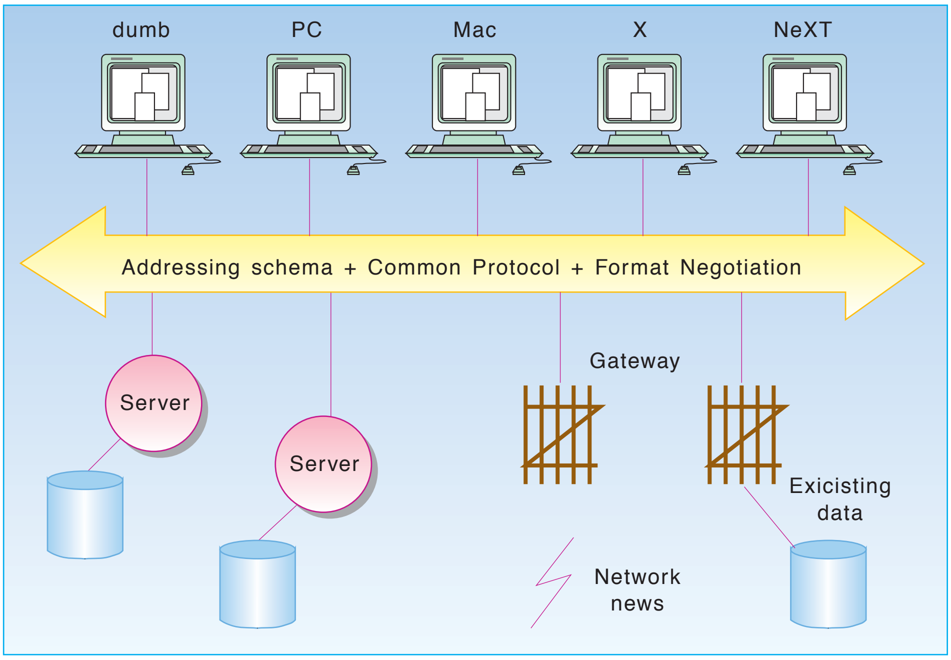


Figure 8 World-Wide Web has a flexible architecture that allows most networked computers to access the WWW server

Typically, an information vendor uses proprietary tools and formats for manipulating information. One of the major problems in establishing a prototype for an electronic marketplace is to transform these formats into HTML which is used by MultiTorg. In most cases, the information vendor will not be interested in introducing new tools supporting the HTML format. In order to ease the "Tower of Babel", translators have been built.

- News. One such translator converts the stream of data coming out of NTB's newswire. NTB (Norsk Telegram Byrå) is Norway's primary news agency.
- Norwegian Telecom Research (NTR) annually publishes approximately 100 research reports. A typical report is created on a computer, printed out and copied on paper. To access the content of these reports, one has to have physical copies available. There are obvious benefits to making reports available in electronic form.

  Since most of NTR's reports are written in FrameMaker, even using the same style-sheets, the translation is fairly straightforward. We have built translators for the FrameMaker Interchange Format (MIF) to HTML. MIF contains, among other features, a logical structure which is the target for translation to the logical HTML format. In addition to text, graphics and images are preserved in the translation process. Several problems arise because of the richness of MIF compared to the relatively simple HTML format. E.g., how should mathematical notation – a substructure not supported by HTML – be translated?
- Gateway servers. In most cases, HTTP servers fetches files from a local disk and serves them over the net to a requesting client application. However, one can also build HTTP servers that stand as gateways between clients and other interactive services. We have implemented one such service over the X.500 catalogue service.
- Multimedia. To show the potential of audio and video in an information system context, MultiTorg includes an electronic jukebox and a video store. In the electronic jukebox, users can select their favourite music. Currently, the selection is limited to 1 GB true CD-quality audio, but a variety of genres are represented. The bandwidth

Figure 9 MultiTorg is making various kinds of information available on-line

requirements of high-quality audio (around 1.5 Mbit/s) prohibit a wide-area distribution.

In the video store MultiTorg includes video samples from different video sources – typically movies and newscasts (see figure 10). We have been experimenting with both software and hardware coding. Sequential JPEG with hardware support offers video-on-demand in the quality range of VHS.

4.3 Why is MultiTorg based on Internet protocols and WWW?

The Internet is a global computer network. The number of connected computers is growing very fast. The network contains millions of users, an enormous test bed for new services.

Much of the core software of MultiTorg is developed by people strongly attached to the Internet, and their software is freely distributed there. World Wide Web is emerging as the preferred way of distributing and accessing information on the Internet due to a number of reasons:

- HTTP is a simple protocol which it is easy to write software for.
- HTML is a simple, but powerful markup language with support for distributed hypermedia.
- Internet contains interesting information that was waiting for a system beyond file transfer.
- The availability of most software in source code form encourages co-operation and the sharing of ideas and bug-fixes.

During the last year several thousand new WWW servers have been installed, of which MultiTorg is one. This global information network contains vast amounts of information, but the information is restricted to those of us that are "on the net".

WWW runs on top of the TCP/IP protocol suite; the basis of the Internet. As the Internet increasingly takes advantage of broadband connections, we will see the introduction of services based on continuous media like video and audio. We believe WWW is a foundation that will scale to also include these media types.

4.4 Unanswered questions

Having established an arena for experiments, we have located areas where a technical and social development should or will take place.

- The previously described distinction between information producers and consumers may fade away. The network is inherently a two-way medium which opens for user participation. We are seeing the beginning of this on the computer conferences on the net; given a chance, people will respond.
- The lack of layout information in HTML is considered a defect by many. Professional information producers want to be able to enhance the presentation with information regarding fonts, columns, placement, etc. There is an unresolved tension between the sender and recipient of information – who is to be in charge of the final form presentation? HTML clearly champions the recipient.
- In order to create a marketplace the information vendors have to be able to see profits, and accounting needs to be introduced. Different schemes exist for the monetary transactions that will take place, e.g. "pay-per-view" and "subscription".
- Another vital function is authentication. Currently, the MultiTorg server distinguishes between requests on the basis of machine names. The authentication resolution needs to be heightened in order to create a marketplace.
- The World Wide Web has no elegant support for continuous media. As discussed above, the WWW system is a hypermedia system based on a client-server architecture. If the user reads a link in the hypertext system the client

will ask the server for the document that the link is pointing to. The server will then transport the document to the client. Current clients will not try to present the document before the entire document is received. This is unacceptable if the document is a video-film, an everlasting audio source or a real-time computer game.

5 Discussion and conclusion

The number of computers connected in networks is growing fast. New broadband networks will provide a communication highway were new services will emerge. Information will be the basis for all these new services.

In a not too distant future, there will exist an open electronic marketplace for information. We believe the Internet and the emerging WWW technology should be seriously considered as foundations for such a market.

In MultiTorg, we have developed several prototypes for converting formats, accessing distributed documents, and presenting information through various media.

The "Tower of Babel" on computer networks is an important and problematic issue, and applications will continue to use native formats. Although several candidates for universal formats exist, it is not likely that one format will be dominant in the next decade. Rather, we should concentrate on building translation utilities.

6 Acknowledgement

We would like to thank Kåre Andersen of NTB for productive co-operation.

Figure 10 The movie "The little mermaid" is available on demand in MultiTorg

Media streams: an iconic visual language for video annotation

BY MARC DAVIS

Abstract

659.3

In order to enable the search and retrieval of video from large archives, we need a representation of video content. Although some aspects of video can be automatically parsed, a detailed representation requires that video be annotated. We discuss the design criteria for a video annotation language with special attention to the issue of creating a global, reusable video archive. We outline in detail the iconic visual language we have developed and a stream-based representation of video data.

Our prototype system, Media Streams, enables users to create multi-layered, iconic annotations of video content. Within Media Streams, the organisation and categories of the Director's Workshop allow users to browse and compound over 2500 iconic primitives by means of a cascading hierarchical structure which supports compounding icons across branches of the hierarchy. Icon Palettes enable users to group related sets of iconic descriptors, use these descriptors to annotate video content, and reuse descriptive effort. Media Time Lines enable users to visualise and browse the structure of video content and its annotations. The problems of creating a representation of action for video are given special attention, as well as describing transitions in video.

1 Introduction: the need for video annotation

The central problem in the creation of robust and extensible systems for manipulating video information lies in representing and visualising video content. Currently, content providers possess large archives of film and video for which they lack sufficient tools for search and retrieval. For the types of applications that will be developed in the near future (interactive television, personalised news, video on demand, etc.) these archives will remain a largely untapped resource, unless we are able to access their contents. Without a way of accessing video information in terms of its content, a thousand hours of video is less useful than one. With one hour of video, its content can be stored in human memory, but as we move up in orders of magnitude, we need to find ways of creating machine-readable and human-usable representations of video content. It is not simply a matter of cataloguing reels or tapes, but of representing and manipulating the content of video at multiple levels of granularity and with greater descriptive richness. This paper attempts to address that challenge.

Given the current state of the art in machine vision and image processing, we cannot now, and probably will not be able to for a long time, have machines "watch" and understand the content of digital video archives for us. Unlike text, for which we have developed sophisticated parsing technologies, and which is accessible to processing in various structured forms (ASCII, RTF, PostScript), video is still largely opaque. We are currently able to automatically analyse scene breaks, pauses in the audio, and camera pans and zooms (41, 21, 31, 33, 34, 38, 39), yet this information alone does not enable the creation of a sufficiently detailed representation of video content to support content-based retrieval and repurposing.

In the near term, it is computer-supported human annotation that will enable video to become a rich, structured data type. At this juncture, the key challenge is to develop solutions for people who already devote time and money to annotating video, because they will help create the necessary infrastructure (both economically and in terms of the content itself) to support the ubiquitous use and reuse of video information. Today, simple queries often take tens of hours and cost thousands of dollars. If recorded reusable video is going to become a ubiquitous medium of daily communication, we will need to develop technologies which will change the current economics of annotation and retrieval.

1.1 Video annotation today

In developing a structured representation of video content for use in annotation and retrieval of video from large archives, it is important to understand the current state of video annotation and to create specifications for how future annotation systems should be able to perform. Consequently, we can posit a hierarchy of the efficacy of annotations:

At least, Pat should be able to use Pat's annotations.

Slightly better, Chris should be able to use Pat's annotations.

Even better, Chris' computer should be able to use Pat's annotations.

At best, Chris' computer and Chris should be able to use Pat's and Pat's computer's annotations.

Today, annotations used by video editors will typically only satisfy the first desideratum (Pat should be able to use Pat's annotations) and only for a limited length of time. Annotations used by video archivists aspire to meet the second desideratum (Chris should be able to use Pat's annotations), yet these annotations often fail to do so if the context of annotation is too distant (in either time or space) from the context of use. Current computer-supported video annotation and retrieval systems use keyword representations of video and ostensibly meet the third desideratum (Chris' computer should be able to use Pat's annotations), but practically do not because of the inability of keyword representations to maintain a consistent and scalable representation of the salient features of video content.

In the main, video has been archived and retrieved as if it were a non-temporal data type which could be adequately represented by keywords. A good example of this approach can be seen in Apple Computer's *Visual almanac* which describes and accesses the contents of its video and image archive by use of "keywords" and "image keys" (4). This technique is successful in retrieving matches in a fairly underspecified search but lacks the level of granularity and descriptive richness necessary for computer-assisted and automatic video retrieval and repurposing. The keyword approach is inadequate for representing video content for the following reasons:

- Keywords do not describe the complex *temporal* structure of video and audio information.
- Keywords are not a *semantic* representation. They do not support inheritance, similarity, or inference between descriptors. Looking for shots of "dogs" will not retrieve shots indexed as "German shepherds" and vice versa.
- Keywords do not describe *relations* between descriptions. A search using the keywords "man," "dog," and "bite"

may retrieve “dog bites man” videos as well as “man bites dog” videos – the relations between the descriptions highly determine salience and are not represented by keyword descriptions alone.

- Keywords do not *scale*. As the number of keywords grows, the possibility of matching the query to the annotation diminishes. As the size of the keyword vocabulary increases, the precision and recall of searches decrease.

Current paradigms of video representation are drawn from practices which arose primarily out of “single-use” video applications. In single-use applications, video is shot, annotated, and edited for a given movie, television program, or video. Annotations are created for one single use of the video data. There do exist certain cases today, like network news archives, film archives, and stock footage houses, in which video is used multiple times, but the level of granularity of the annotation and the semantics of the annotations do not support a wide reusability of video content. The challenge is to create representations which support “multi-use” applications of video. These are applications in which video may be dynamically resegmented, retrieved, and resequenced on the fly by a wide range of users *other than those who originally created the data*.

Today, in organisations and companies around the world whose business it is to annotate, archive, and retrieve video information, by and large, the structure of the data is mostly represented in the memories of the human beings whose job it is to handle it. Even in situations in which keyword-based computer annotation systems are “used,” short-term memory and long-term memory are the real repositories of information about the content of video data. “Joe and Jane in the basement” are the real indexing and retrieval mechanisms in almost all video archives. Human memory is very good at retrieving video due to its associative and analogical capabilities; it has memory structures which any computerised retrieval system would want to emulate. Nevertheless, there are significant problems in sharing the contents of one human memory with others and of transferring the contents of one human memory to another. There are also severe limitations in terms of storage capacity and speed for human memory that aren’t acceptable if we are going to scale up to a global media archive in which video is accessed and manipulated by millions of people everyday.

We need to create a language for the representation of video content which enables us to combine automatic, semi-automatic, and human annotation so as to be able to make use of today’s annotation effort long into the future.

1.2 Video annotation tomorrow

In the near future, we can imagine a world in which video annotation, search, and retrieval are conducted not just by professionals for professionals, but by anyone interested in repurposing footage. In a world where digital media are produced anywhere by anyone and are accessible to anyone anywhere, video will need to accrete layers of content annotations as it moves around the globe throughout its life cycle of use and reuse. In the future, annotation, both automatic and semi-automatic, will need to be fully integrated into the production, archiving, retrieval, and reuse of video and audio data. In production, cameras will encode and interpret detailed information about where, when, and how they are recording and attach that information to the digital data stream: global satellite locators will indicate altitude, longitude and latitude, time will be stamped into the bit stream, other types of sensing data – temperature, humidity, wind – as well as how the camera moves (pans, zooms, etc.) and how far away the camera is from its subjects (range data for example) will all provide useful layers of annotation of the stream of video and audio data which the camera produces. Still there will exist many other annotations of a more semantic nature which these cameras won’t be able to automatically encode, and for which we will want to have formats so that humans working with machines will be able to easily annotate video content. In a sense, the challenge is to develop a language of description which humans can read and write and which computers can read and write which will enable the integrated description and creation of video data. Such a language would satisfy the fourth desideratum of video annotation (Chris’ computer and Chris should be able to use Pat’s and Pat’s computer’s annotations).

By having a structured representation of video content – meaningful bits about the bits – future annotation and retrieval technology will enable users to mix video streams according to their contents and to manipulate video at various levels of granularity. With this kind of representation, annotation, and retrieval technology we will create tools which enable users to operate on higher level content structures of video data instead of being stuck with just bits, pixels, frames, or clips.

2 Design criteria for video annotation languages

A language for video annotation needs to support the visualisation and browsing of the structure of video content as well as search and retrieval of video content. There has been some excellent work in visualising and browsing video data (37, 40, 31, 33, 21) with which our work has affinity. The limitations of these systems rest in the question of their scalability and, a related problem, their lack of a developed video annotation language. For as visualisation and browsing interfaces must accommodate larger and larger video databases, they need to be able to work with video according to its content as well as its structure, and hence, annotation and retrieval become necessary components of the system.

A video annotation language needs to create representations that are durable and sharable. The knowledge encoded in the annotation language needs to extend in time longer than one person’s memory or even a collective memory, and needs to extend in space across continents and cultures. Today, and increasingly, content providers have global reach. German news teams may shoot footage in Brazil for South Korean television which is then accessed by American documentary film makers, perhaps ten years later. We need a global media archiving system that can be added to and accessed by people who do not share a common language, and the knowledge of whose contents is not only housed in the memories of a few people working in the basements of news reporting and film production facilities. Visual languages may enable the design of an annotation language with which we can create a truly global media resource. Unlike other visual languages that are used internationally (e.g., for traffic signage, operating instructions on machines, etc. (18)) a visual language for video annotation can take advantage of the affordances of the computer medium. We can develop visual languages for video that utilise colour, animation, variable resolution, and sound in order to create durable and sharable representations of video content.

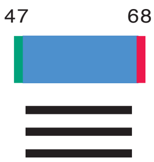
3 Representing video

3.1 Streams vs. clips

In designing a visual language for video content we must think about the structure of what is being represented. A video camera produces a temporal stream of image and sound data represented as a sequence of frames played back at a certain rate – normally 30 frames per second. Traditionally, this stream of frames is segmented into units called clips. Current tools for annotating video content used in film production, television production, and multimedia, add descriptors (often keywords) to clips. There is a significant problem with this approach. By taking an incoming video stream, segmenting it into various clips, and then annotating the content of those clips, we create a fixed segmentation of the content of the video stream. Imagine a camera recording a sequence of 100 frames.

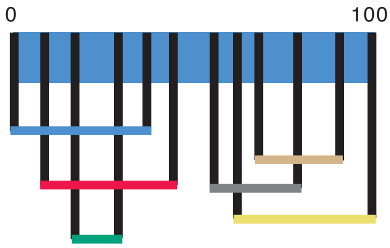
Stream of 100 frames of video

Traditionally, one or more parts of the stream of frames would be segmented into clips which would then be annotated by attaching descriptors. The clip is a fixed segmentation of the video stream that separates the video from its context of origin and encodes a particular chunking of the original data.



A "clip" from frame 47 to frame 68 with descriptors

In our representation, the stream of frames is left intact and is annotated by multi-layered annotations with precise time indexes (beginning and ending points in the video stream). Annotations could be made within any of the various categories for media annotation discussed below (e.g., characters, spatial location, camera motion, dialogue, etc.) or contain any data the user may wish. The result is that this representation makes annotation pay off – the richer the annotation, the more numerous the possible segmentations of the video stream. Clips change from being fixed segmentations of the video stream, to being the results of retrieval queries based on annotations of the video stream. In short, in addressing the challenges of representing video for large archives what we need are representations which make clips, not representations of clips.



The stream of 100 frames of video with 6 annotations resulting in 66 possible segmentations of the stream (i.e., "clips")

3.2 Categories for media annotation

A central question in our research is the development of a minimal representation of video content. This has resulted in the development of a set of categories for, and a way of thinking about, describing video content. Let us build up these categories from examining the qualities of video as a medium. One of the principal things that makes video unique is that it is a temporal medium. Any language for annotating the content of video must have a way of talking about temporal events – the actions of humans and objects in space over time. Therefore, we also need a way of talking about the characters and objects involved in actions as well as their setting, that is, the spatial location, temporal location, and weather/lighting conditions. The objects and characters involved in actions in particular settings also have significant positions in space relative to one another (beneath, above, inside, outside, etc.).

These categories – *actions, characters, objects, locations, times, and weather* – would be nearly sufficient for talking about actions in the world, but video is a *recording* of actions in the world by a camera, and any representation of video content must address further specific properties. First, we need ways of talking about *cinematographic properties,* the movement and framing of the camera recording events in the world. We also need to describe the properties of the *recording medium* itself (film or video, colour or black & white, graininess, etc.). Furthermore, in video, viewers see events depicted on screens, and therefore, in addition to relative positions in space, screen objects have a position in the two-dimensional grid of the frame and in the various layered vertical planes of the screen depth. Finally, video recordings of events can be manipulated as objects and rearranged. We create transitions in video in ways not possible in the real world. Therefore, *cinematic transitions* must also be represented in an annotation language for video content.

These categories need not be *sufficient* for media annotation (the range of potential things one can say is unbounded), but we believe they are *necessary* categories for media annotation in order to support retrieval and reuse of particular segments of video data from an annotated stream.

These minimal annotation categories attempt to represent information about media content that can function as a substrate:

- on top of which other annotations may be layered
- out of which new annotations may be inferred
- within which the differences between consensual and idiosyncratic annotations may be articulated.

3.3 Video syntax and semantics

In attempting to create a representation of video content, an understanding of the semantics and syntax of video information is a primary concern. Video has a radically different semantic and syntactic structure than text, and attempts to represent video and index it in ways similar to text will suffer serious problems.

First of all, it is important to realise that video images have very little intrinsic semantics. Syntax is highly determinative of their semantics, as evidenced by the Kuleshov Effect (30). The Kuleshov Effect is named after Lev Kuleshov, a Soviet cinematographer whose work at the beginning of the century deeply influenced the Soviet montage school and all later Soviet cinema (19, 20). Kuleshov was himself an engineer who, after only having worked on one film, ended up heading the Soviet film school after the October Revolution. Kuleshov was fascinated by the ability of cinema to create artificial spaces and objects through montage (editing) by virtue of the associations people create when viewing sequences of shots, which if the shots were taken out of sequence would not be created. In the classic Kuleshov example,

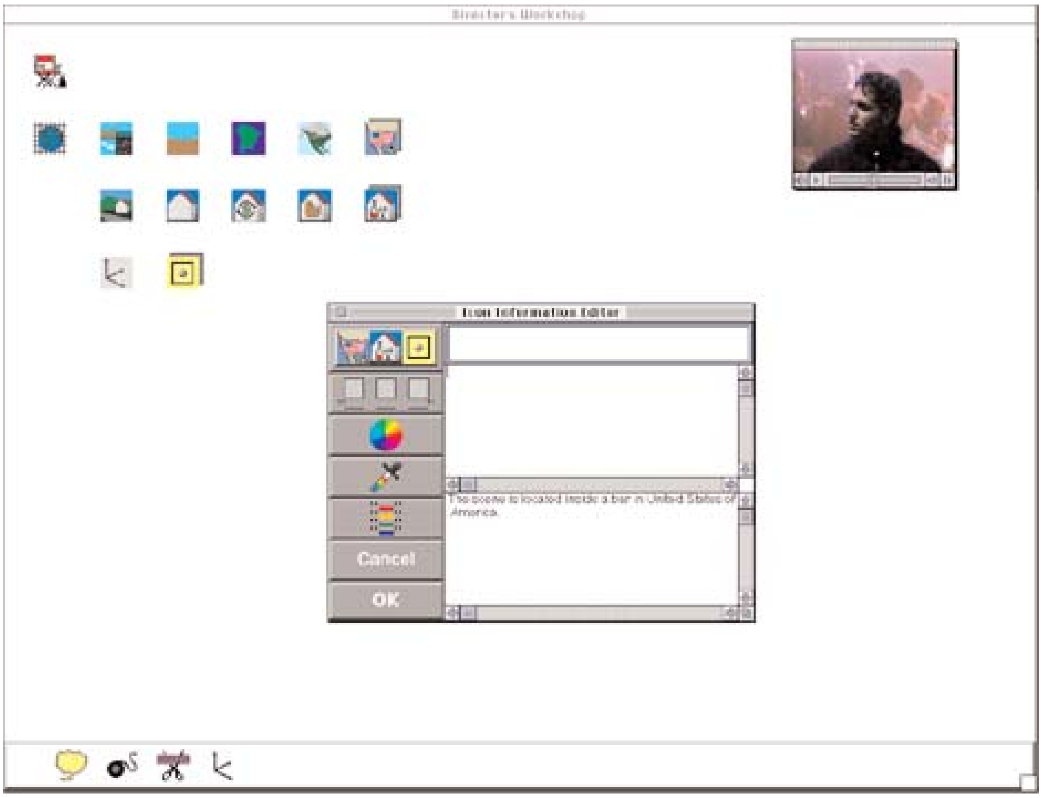


Figure 1 Director's Workshop

Kuleshov showed the following sequence to an audience:

the passive face of an actor – a bowl of soup – go to black

the same face of the actor – a coffin – go to black

the same face of the actor – a field of flowers – go to black.

Upon interviewing audience members and asking them what they saw, they said, "Oh, he was hungry, then he was sad, then he was happy." The same exact image of the actor's face was used in each of the three short sequences. What the Kuleshov Effect tells us then is that the semantics of video information is highly determined by what comes before and what comes after any given shot. It is the Kuleshov Effect which makes the construction of cinematic sequences possible at all and which enables us to reuse existing footage to make new sequences.

The syntax of video sequences determines the semantics of video data to such a degree that any attempts to create context-free semantic annotations for video must be carefully scrutinised so as to determine which components are context-dependent and which preserve their basic semantics through recombination and repurposing. Any indexing or representational scheme for the content of video information needs to be able to facilitate our understanding of how the semantics of video changes when it is resequenced into new syntactic structures. Therefore, the challenge is twofold: to develop a representation of those salient features of video which, when combined syntactically, create new meanings; and to represent those features which do not radically change when recontextualised.

4 Media Streams: an overview

Over the past two years, members of the MIT Media Laboratory's Learning and Common Sense Section (Marc Davis with the assistance of Brian Williams and Golan Levin under the direction of Prof. Kenneth Haase) have been building a prototype for the annotation and retrieval of video information. This system is called *Media Streams*.[1] Media Streams has developed into a working system that soon will be used by other researchers at the Media Lab and in various projects in which content annotated temporal media are required. Media Streams is written in Macintosh Common Lisp (2) and FRAMER (25, 24), a persistent framework for media annotation and description that supports cross-platform knowledge representation and database functionality. Media Streams has its own Lisp interface to Apple's QuickTime digital video system software (3). Media Streams is being developed on an Apple Macintosh Quadra 950 with three high resolution colour displays.

The system has three main interface components: the Director's Workshop (see figure 1); icon palettes (see figure 2); and media time lines (see figure 3). The process of annotating video in Media Streams using these components involves a few simple steps:

1) In the Director's Workshop, the user creates iconic descriptors by cascading down hierarchies of icons in order to select or compound iconic primitives.
2) As the user creates iconic descriptors, they accumulate on one or more icon palettes. This process effectively groups related iconic descriptors. The user builds up icon palettes for various types of default scenes in which iconic descriptors are likely to co-occur, for example, an icon palette for "treaty signings" would contain icons for certain dignitaries, a treaty, journalists, the action of writing, a stateroom, etc.
3) By dragging iconic descriptors from icon palettes and dropping them onto a media time line, the user annotates the temporal media represented in the media time line. Once dropped onto a media time line, an iconic description extends from its insertion point in the video stream to either a scene break or the end of the video stream. In addition to dropping individual icons onto the media time line, the user can construct compound icon sentences by dropping certain "glommable" icons onto the Media Time Line, which, when com-

[1] A paper on an early version of this system was presented at the AAAI-91 Workshop on Intelligent Multimedia Interfaces (14) and a shorter version of this current paper was presented at the 1993 IEEE Symposium on Visual Languages in Bergen, Norway (15).

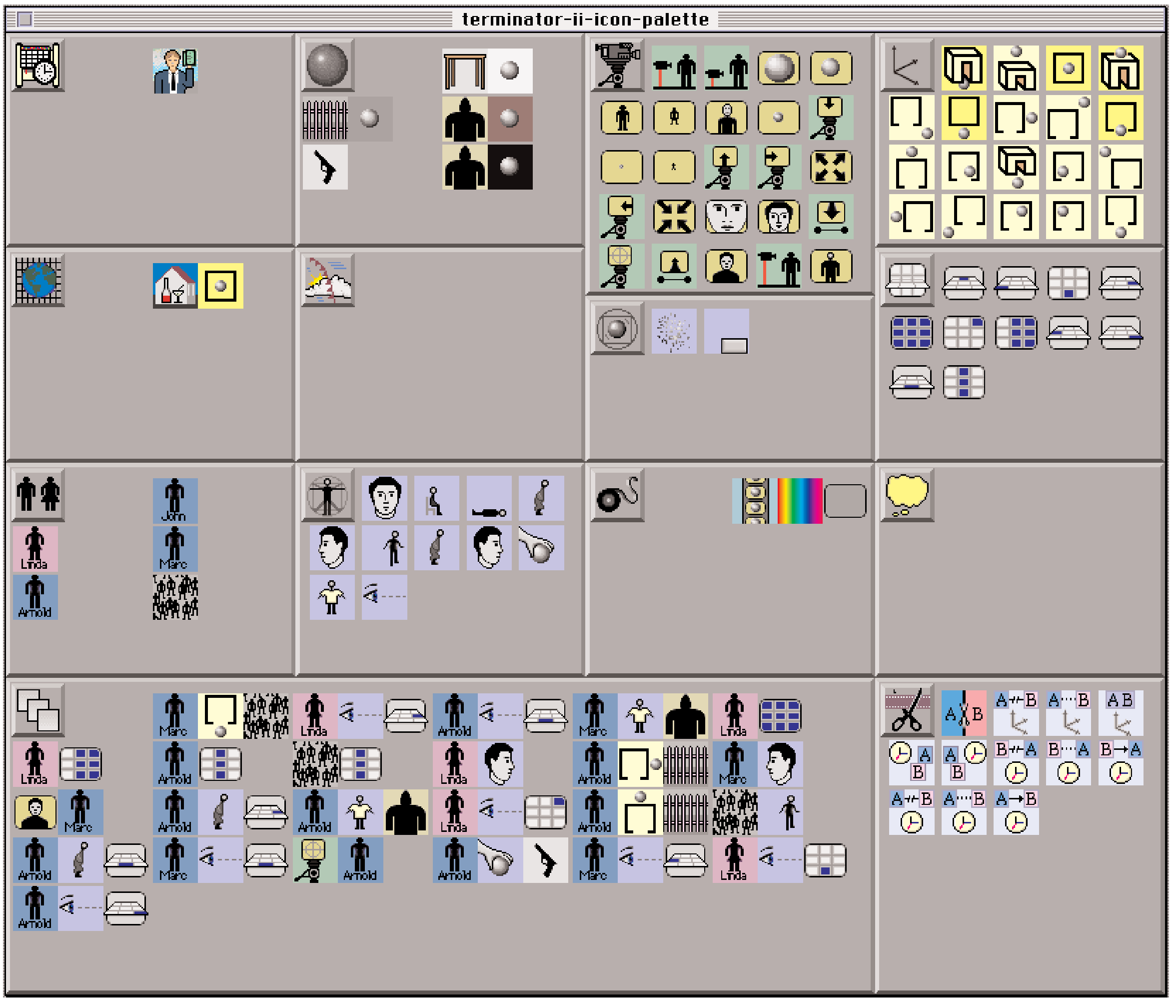
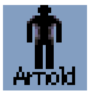
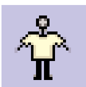
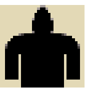


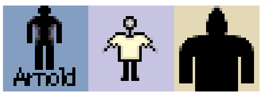
Figure 2 Icon Palette

pleted, are then added to the relevant Icon Palette and may themselves be used as primitives. For example, the user initially builds up the compound icon sentence for "Arnold, an adult male, wears a jacket" by successively dropping the

icons 

,  and

 onto the media time line. The user then has the compound icon



on an icon palette to use in later annotation. By annotating various aspects of the video stream (time, space, characters, character actions, camera motions, etc.), the user constructs a multi-layered, temporally indexed representation of video content.

Media Streams is a large system that attempts to address many questions in video representation. In this paper we will focus on Media Streams' language for video annotation. It is an iconic visual language that allows composition of iconic primitives in order to form complex expressions. It has a syntax for the composition of iconic sentences and means for extending the visual language.

5 Why icons?

There have been serious efforts to create iconic languages to facilitate global communication (7) and provide international standard symbols for specific domains (18). We developed Media Streams' iconic visual language in response to trying to meet the needs of annotating video content in large archives. It seeks to enable:

- quick recognition and browsing of content annotations
- visualisation of the dense, multi-layered temporal structure of video content
- an accurate and readable time-indexed representation of simultaneous, sequential, overlapping and contained actions (natural languages are not very good at this task)
- articulation of the boundaries between consensual and idiosyncratic annotations (icons can have attached textual annotations and can thus function as the explicit consensual tokens of various idiosyncratic textual descriptions)
- global, international use of annotations
- visual similarities between instances or subclasses of a class (visual resonances in the iconic language).

Media Streams' iconic language encompasses icons which denote both things and actions and thus embodies a distinction analogous to Chang's (12) distinction between object icons and process icons. The difference here is that the objects and processes denoted by the Media Streams' icons are not computational ones, but aspects of the video content which they annotate.

The iconic language gains expressive power and range from the compounding of primitives and has set grammars of combination for various categories of icons. In Korfhage's sense Media Streams is an iconic language as opposed

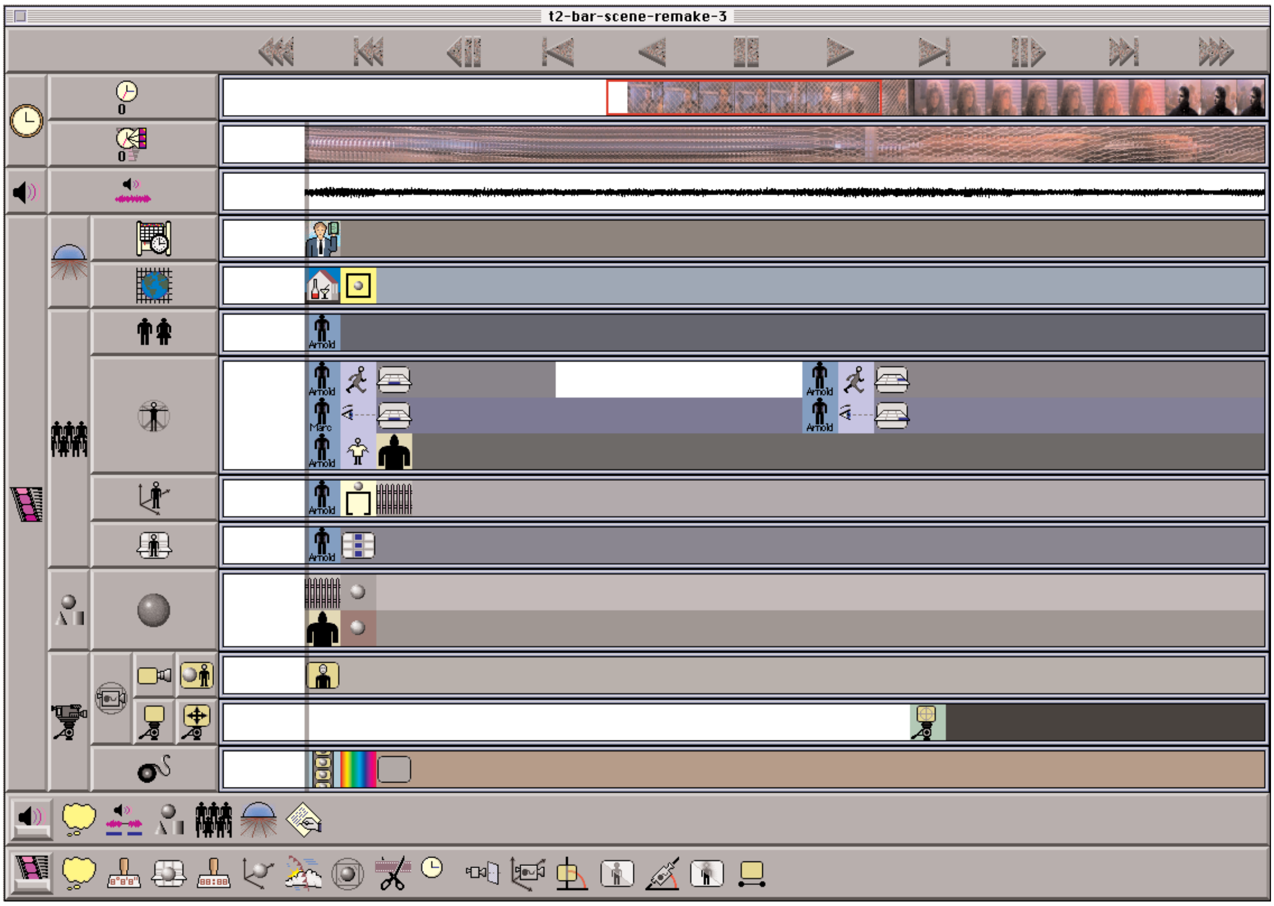
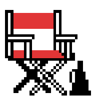


Figure 3 Media Time Line

to being merely an iconography (28). Similar to other syntaxes for iconic sentences (13, 35) icon sentences for actions have the form of subject-action, subject-action-object, or subject-action-direction, while those for relative positions have the form subject-relative position-object. Icon sentences for screen positions are of the form subject-screen position, while cinematographic properties are of the form camera-movement-object (analogous to subject-action-object), as in "the camera-is tracking-Steve" or "the camera-zooms in on-Sally."

6 Director's Workshop



The Director's Workshop is the interface for the selection and compounding of the iconic primitives in Media Streams (see figure 1). To date we have over 2500 iconic primitives. What enables the user to navigate and make use of such a large number of primitives is the way the Director's Workshop organises these icons into cascading hierarchies. We refer to the iconic primitives in the Director's Workshop as "cascading icons." The Director's Workshop has two significant forms of organisation for managing navigational and descriptive complexity:

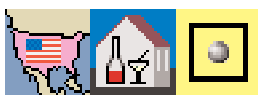
- *Cascading hierarchy with increasing specificity of primitives on subordinate levels*

  Cascading icons are organised in hierarchies from levels of generality to increasing levels of specificity. Similar to cascading menus on the Macintosh, when a user cascades down an icon hierarchy by clicking on a cascading icon, its subordinate icons are displayed to the right of the cascading icon. These subordinate icons are arranged horizontally and represent an increased level of specificity. Some of the icon hierarchies cascade to as many as 7 or 8 levels deep, yet, similarly to the semantic hierarchies of the CYC Project (29), the design of the categories themselves and their first three or four levels is the hardest and most important representational task.

- *Compounding of hierarchically organised primitives across multiple axes of description*

  In many icon hierarchies on the Director's Workshop, there exists an additional form of organisation. When subordinate icons are arranged vertically, they represent independent axes of description whose icon hierarchies can be cascaded through separately and whose respective subordinate icons can be compounded together across these axes to form compound iconic descriptors. This form of organisation enables a relatively small set of primitives to be compounded into a very large and rich set of descriptors.

To illustrate these forms of organisation in our iconic language we can look at how to create the icon for "the scene is located inside a bar in United States of America,"



which appears in the Icon Information Editor. Figure 1 shows the cascading icon hierarchy for "space" extended out to the icons for "United States of America," "bar," and "inside" which the user compounded to create the icon for "the scene is located on top of a street in Texas" which appears in the Icon Information Editor. The user clicked on the space icon, which cascaded to show its subordinate icons "geographical space," "functional space," and "topological space" *vertically* arranged. Each of these cascading icons has further *horizontally* arranged subordinate icons each of which may go several levels deep. For example, the icons in the path from "geographical space" to "United States of America" each represents a distinct level of progressive specification (geographical space->land->continent-> North America->United States of America). As indicated by the grey square behind the "United States of America" icon, it too has further levels of specificity below it which can be displayed by clicking on the icon. In the Director's Workshop, at all but the terminal levels in the hierarchy, there exist many icons which themselves have further levels of specification. At any level in the hierarchy, icons can be compounded across the vertical organisation to create compound icons. In addition to clicking, cascading icons can be accessed by voice (using the Voice Navigator II™), by typing in text for their names, or by dropping an existing icon onto the Director's Workshop which opens the icon hierarchies up to the terminals of the components of the dropped icon. In all these ways, a vast, but structured space of icons can be easily navigated by the user.

It is also important to note that the icon hierarchy of the Director's Workshop is structured not as a tree, but as a graph. The same iconic primitives can often be reached by multiple paths. The system encodes the paths users take to get to these primitives; this enriches the representation of the compounds which are constructed out of these primitives. This is especially useful in the organisation of object icons, in which, for example, the icon for "blow-dryer" may be reached under "hand-held device," "heat-producing device," or "personal device." These paths are also very important in retrieval, because they can guide generalisation and specialisation of search criteria by functioning as a semantic net of hierarchically organised classes, subclasses, and instances.

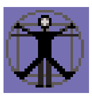
6.1 A language for action

The central problem of a descriptive language for temporal media is the representation of dynamic events. For video in particular, the challenge is to come up with techniques for representing and visualising the complex structure of the actions of characters, objects, and cameras. There exists significant work in the normalisation of temporal events in order to support inferencing about their interrelationships (1) and to facilitate the compression and retrieval of image sequences by indexing temporal and spatial changes (5, 16, 17). Our work creates a representation of cinematic action which these and other techniques could be usefully applied to. For even if we had robust machine vision, temporal and spatial logics would still require a *representation* of the video content, because such a representation would determine the units these formalisations would operate on for indexing, compression, retrieval, and inferencing.

A representation of cinematic action for video retrieval and repurposing needs to focus on the granularity, reusability, and semantics of its units. In representing the action of bodies in space, the representation needs to support the hierarchical decomposition of its units both spatially and temporally. Spatial decomposition is supported by a representation that hierarchically orders the bodies and their parts which participate in an action. For example, in a complex action like driving an automobile, the arms, head, eyes, and legs all function independently. Temporal decomposition is enabled by a hierarchical organisation of units, such that longer sequences of action can be broken down into their temporal subabstractions all the way down to their atomic units. In (29), Lenat points out the need for more than a purely temporal representation of events that would include semantically relevant atomic units organised into various temporal patterns (repeated cycles, scripts, etc.). For example, the atomic unit of "walking" would be "taking a step" which repeats cyclically. An atomic unit of "opening a jar" would be "turning the lid" (which itself could theoretically be broken down into smaller units – but much of the challenge of representing action is knowing what levels of granularity are useful).

Our approach tries to address these issues in multiple ways with special attention paid to the problems of representing human action as it appears in video. It is important to note in this regard – and this holds true for all aspects of representing the content of video – that unlike the project of traditional knowledge representation which seeks to represent the world, our project is *to represent a representation of the world*. This distinction has significant consequences for the representation of human action in video. In video, actions and their units do not have a fixed semantics, because their meaning can shift as the video is recut and inserted into new sequences (30, 27). For example, a shot of two people shaking hands, if positioned at the beginning of a sequence depicting a business meeting, could represent "greeting," if positioned at the end, the same shot could represent "agreeing." Video brings to our attention the effects of context and order on the meaning of represented action. In addition, the prospect of annotating video for a global media archive brings forward an issue which traditional knowledge representation has largely ignored: cultural variance. The shot of two people shaking hands may signify greeting or agreeing in some cultures, but in others it does not. How are we to annotate shots of people bowing, shaking hands, waving hello and good-bye? The list goes on. In order to address the representational challenges of action in video we do not explicitly annotate actions according to their particular semantics in a given video stream (a shot of two people shaking hands is not annotated as "greeting" or alternately as "agreeing"), but rather according to the motion of objects and people in space. We annotate using physically-based description in order to support the reuse of annotated video in different contexts – be they cinematic or cultural ones. We create analogy mappings between these physically-based annotations in their concrete contexts in order to represent their contextual synonymy or lack thereof.

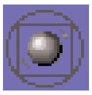
6.2 Character actions and object actions



We subdivide character actions *horizontally* into full body actions, head actions, arm actions, and leg actions (see figure 4). Under each of these categories of human action (and their own subdivisions) action is represented in two ways:

- conventionalised physical motions
- abstract physical motions.

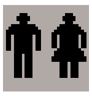
We built into our ontology many commonly occurring, complex patterns of human motion which seem to have cross-cultural importance (e.g., walking, sitting, eating, talking, etc.). We also provide a hierarchical decomposition of the possible motions of the human body according to articulations and rotations of joints. Since Media Streams enables multi-layered annotation, any pattern of human motion can be described with precision by layering temporally indexed descriptions of the motion of various human body parts.



Object actions are subdivided *horizontally* into actions involving a single object, two objects, or groups of objects (see figure 5). Each of these is divided according to object *motions* and object *state changes*. For example, the action of a ball rolling is an object motion; the action of a ball burning is an object state change.

We represent actions for characters and objects separately in the Director's Workshop because of the unique actions afforded by the human form. Our icons for action are *animated* which takes advantage of the affordances of iconography in the computer medium as opposed to those of traditional graphic arts.

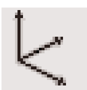
6.3 Characters and objects



Characters are subdivided *vertically* into characters (female, male, unknown gender, non-human, and crowd), occupations (personal care, commercial, institutional, religious, sports) and number (one, two, three ... many) (see figure 6). Characters do not have "essential" identities in cinema. Characters are what they seem to be. For our purposes, someone dressed like a doctor is a doctor. Marcus Welby is an MD.

Objects are subdivided *vertically* into various types of objects and number of objects.

6.4 Relative positions



Relative positions are used to describe the spatial relationship between characters and objects and are subdivided *horizontally* into inside, on the threshold of, outside, on top of, underneath, above, and below.

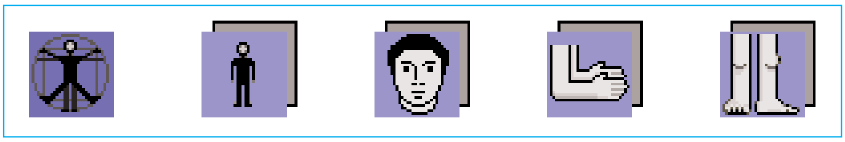


Figure 4 Character actions

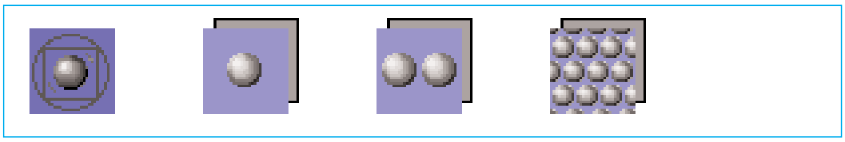
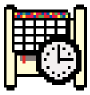
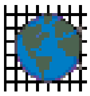


Figure 5 Object actions

6.5 Mise-en-scene: time, space, and weather



Time is subdivided *vertically* into historical period (from the age of the dinosaurs through the twentieth century on into the future), time of year (spring, summer, fall, and winter), and time of day or night (morning, afternoon, sunset, midnight, etc.) (see figure 7).



Space is subdivided *vertically* into geographical space (land, sea, air, and outer space), functional space (buildings, public outdoor spaces, wilderness, and vehicles), and topological space (inside, outside, above, behind, underneath, etc.) (see figure 8).

Weather is subdivided *vertically* into moisture (clear, partly sunny, partly cloudy, overcast, rainy, and snowy) and wind (no wind, slight wind, moderate wind, and heavy wind) (see figure 9). Temperature is not something that can be directly seen. A video of a cold clear day may look exactly like a video of a hot clear day. It is the presence of snow or ice that indirectly indicates the temperature.

We use these icons to represent two very different types of space, time, and weather on a Media Time Line: the actual time, space, and weather of the recorded video and the visually inferable time, space, and weather of the video. The difference can be made clear in the following example. Imagine a shot of a dark alley in Paris that looks like a generic dark alley of any industrialised city in Europe (it has no distinguishing signs in the video image which would identify it as a *Parisian* dark alley). The actual recorded time, space, and weather for this shot differ from its visually inferable time, space, and weather. This distinction is vital to any representation for

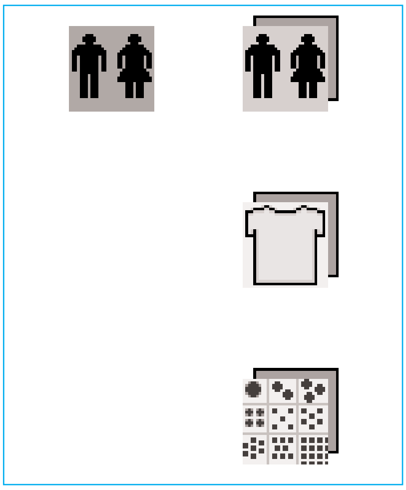
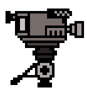


Figure 6 Characters

reusable archives of video data, because it captures both the scope within which a piece of video can be reused and the representality of a piece of video, i.e., some shots are more representative of their actual recorded time, space, and weather than others.

6.6 Cinematography



Through discussion with people who have everyday experience with Hollywood production and by researching camera description languages in film theory (10), we have developed a camera language which is both comprehensive and precise. In order to represent the cinematographic aspects of video we conceptualise the motion of the recording device which produced the images which the annotator sees. In cinema, the recording device typically has three interconnected parts which move independently to produce complex camera motions. The lens of the camera moves (to create different framings, zooms, etc.), what the camera is on – either a tripod or someone's hand – moves (to create pans, to track a moving

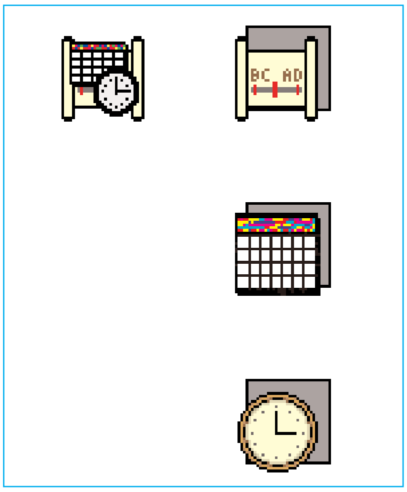


Figure 7 Time

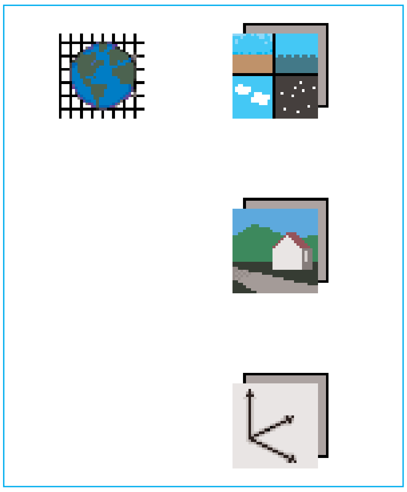


Figure 8 Space

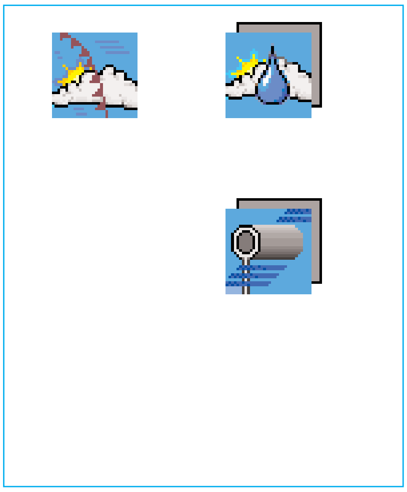


Figure 9 Weather

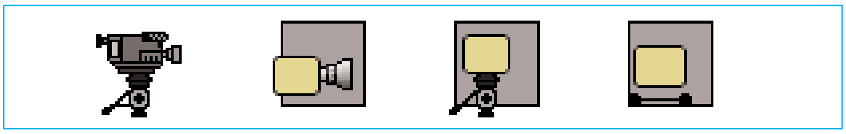
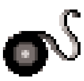


Figure 10 Cinematography

figure), and what the camera is on – a "truck" or "dolly" in cinematic terms, or someone's legs, or even a vehicle as in the case of shots taken from a moving car – may move as well (to create truck in, truck out, etc.). Each part of the recording device may also have important states as in the focus, camera angle, camera height, etc. In Media Streams, camera motions are subdivided *horizontally* into "lens" actions (framing, focus, exposure), "tripod" actions (angle, canting, motion), and "truck" actions (height and motion) (see figure 10). By layering these iconic descriptors on the Media Time Line, the user can describe simple to very complex camera motions.

6.7 Recording medium

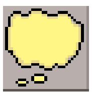


In addition to representing the motions and states of the recording device we also can represent the "look" of the recording medium. Icons for recording medium are subdivided *vertically* into stock (70 mm film, 8 mm video, etc.), colour quality (colour, black & white, sepia, etc.), and graininess (fine, medium, coarse, etc.) (see figure 11).

6.8 Screen positions

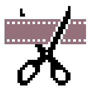
Screen positions are subdivided *horizontally* into two-dimensional screen position and screen depth.

6.9 Thoughts



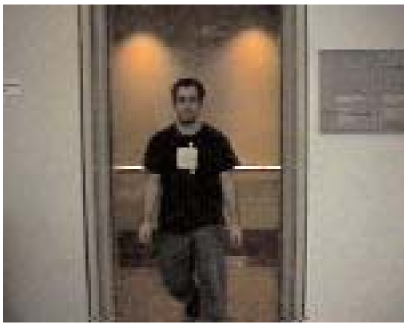
Archivists, for example, would tell us that producers would come to them with queries for footage, saying: "Get me something with a lot of action in it!" Or, regarding the framing of a shot: "I want a well composed shot of three Japanese kids sitting on some steps in Tokyo." These subjective assessments about the qualities of video are addressed in our representation by thoughts' icons which are subdivided *vertically* into thoughts about the screen (framing, activity, colour) and evaluation (from three thumbs up to three thumbs down).

6.10 Transitions



The icon categories described above enable the user to produce representations of the content of video at the shot level. Transitions between shots are both the tools editors use to construct scenes and sequences out of a series of shots, and the gaps in a video stream of recorded space-time which are bridged by the viewer's inferential activity (9, 10). For example, if a viewer sees the two shot sequence:

Shot 1 Person enters elevator, elevator doors close



Shot 2 Elevator doors open, person exits elevator

The viewer infers that a certain amount of time has passed and that a certain type of spatial translation has occurred. Noel Burch has developed a systematic categorisation of spatio-temporal transitions between shots in cinema (11). He divides temporal transitions into continuous, forward ellipses in time of a determinate length, forward ellipses of an indeterminate length, and the corresponding transitions in which there is a temporal reversal. Spatial transitions are divided into continuous, transitions in which spatial proximity is determinate, and transitions in which spatial proximity is indeterminate. Burch's categorisation scheme was used by Gilles Bloch in his groundbreaking work in the automatic construction of cinematic narratives (8). We adopt and extend Burch's categorisation of shot transitions by adding "temporal overlaps" as a type of temporal transition and the category of "visual transitions" for describing transition effects which unlike

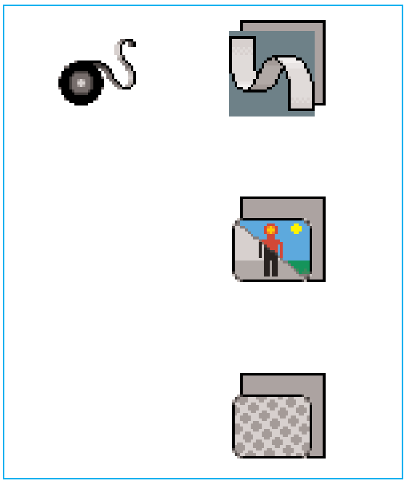


Figure 11 Recording medium

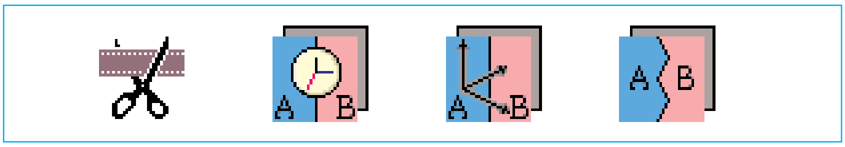
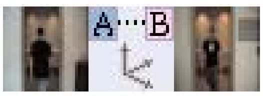


Figure 12 Transitions

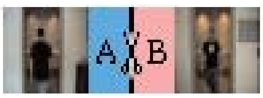
traditional cuts, can themselves have a duration (icons for transition effects which have durations are animated icons). In the Director's Workshop, we *horizontally* subdivide transitions between shots according to temporal transitions, spatial transitions, and visual transitions (cuts, wipes, fades, etc.) (see figure 12).

When a transition icon is dropped on the Media Time Line, Media Streams creates a compound icon in which the first icon is an icon-sized (32 x 32 pixels, 24 bits deep) QuickTime Movie containing the first shot, the second icon is the transition icon, and the third icon is an icon-sized QuickTime Movie containing the shot after the transition. So returning to our example of the two-shot elevator sequence, the compound icons would be as follows:

Temporal transition
(forward temporal ellipsis of a determinate length)



Spatial transition
(spatial translation of a determinate proximity)



Visual transition
(simple cut with no duration)

We intend to use transition icons to improve Media Streams' knowledge about the world and to facilitate new forms of analogical retrieval. A search using the icons above would enable the user to find a "matching" shot in the following way. The user could begin with a shot of a person getting into an automobile and use one or more of the transition icons as analogical search guides in order to retrieve a shot of the person exiting the automobile in a nearby location. The query would have expressed the idea of "find me a Shot B which has a similar relation to Shot A as Shot D has to Shot C."

6.11 Extensibility of the icon language

Currently, we have two ways of extending the iconic visual language of Media Streams beyond the composition of iconic primitives. Icons and the components of compound icons can be titled in the Icon Title Editor of the Icon Information Editor (see figure 13). This enables the user to attain a level of specificity of representation while still making use of the generality and abstraction of icons. For example, if the user were to annotate video of an automobile with the descriptor "XJ7," this description may be very opaque. If, however, the user titles a car icon "XJ7," in addition to the computer learning that XJ7 is a type of car, a human reading this annotation can see simply and quickly the similarity between an XJ7 and other types of automobiles. A form of system maintenance would be to periodically find titles for which there are many occurrences and create an icon for them.

Users can also create new icons for character and object actions by means of the Animated Icon Editor (see figure 14). This editor allows users to define new icons as subsets or mixtures of existing animated icons. This is very useful in conjunction with our complete body model, because a very wide range of possible human motions can be described as subsets or mixtures of existing icons.

Applying the results of work on automatic icon incorporation would be a fruitful path of exploration (22). Already in our icon language, there are many iconic descriptors which we designed using the principle of incorporation (by which individual iconic elements are combined to form new icons). Creating tools to allow users to automatically extend the language in this way is a logical extension of our work in this area.

7 Media Time Lines

The Media Time Line is the core browser and viewer of Media Streams (see figure 3). It enables users to visualise video at multiple time scales simultaneously, to read and write multi-layered iconic annotations, and provides one consistent interface for annotation, browsing, query, and editing of video and audio data.

Since video is a temporal medium, the first challenge for representing and annotating its content is to visualise its content and structure. In the Media Time Line we represent video at multiple time scales simultaneously by trading off temporal and spatial resolution in order to visualise both the content and the dynamics of the video data. We create a sequence of thumbnails of the video stream by subsampling the video stream one frame every second. For longer movies, we sample a frame every minute as well. The spatial resolution of each thumbnail enables the user to visually inspect its contents. However, the temporal resolution is not as informative in that the sequence is being subsampled at one frame per second.

In order to overcome the lack of temporal resolution, we extend a technique pioneered by Ron MacNeil of the Visible Language Workshop of the MIT Media Laboratory (31) and used in the work of Mills and Cohen at Apple Computer's Advanced Technology Group (33). We create a videogram. A videogram is made by grabbing a centre strip from every video frame and concatenating them together. Underneath the subsampled thumbnail frames of the video is the videogram in which the concatenated strip provides fine temporal resolution of the dynamics of the content while sacrificing spatial resolution. Because camera operators often strive to leave significant information within the centre of the frame, a salient trace of spatial resolution is preserved.

In a videogram, a still image has an unusual salience: if a camera pans across a scene and then a centre strip is taken from each video frame, a still will be recreated which is coherently deformed

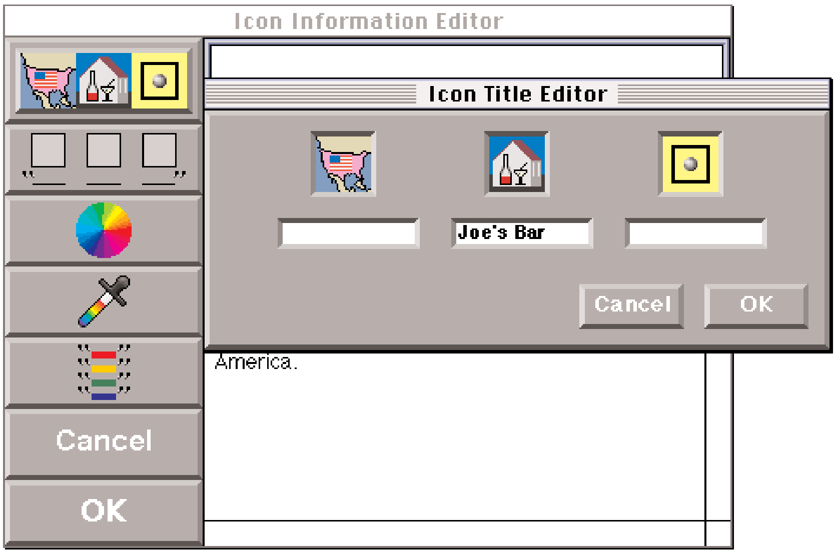


Figure 13 Icon Title Editor

by the pace and direction of the camera motion and/or the pace and direction of any moving objects within the frame. Our contribution is that by simultaneously presenting two different, but co-ordinated views of video data – the thumbnails, with good spatial resolution and poor temporal resolution, and the videogram, with poor spatial resolution but good temporal resolution – the system enables the viewer to use both representations simultaneously in order to visualise the structure of the video information (see figure 15). This idea of playing *spatial* and *temporal* resolutions off one another is also utilised in Laura Teodosio's work on "salient stills" (36) and holds promise as a general guideline for creating new visualisations of video data. An example of this spatial/temporal trade-off can be seen in the figure below in which the movement of Arnold through the frame is visible in the right hand side of the videogram and the fact that swath of extended face corresponds to the central figure can be seen from the thumbnail above.

With little practice, users can learn to read this representation to quickly scan the dynamics of video content from this spatial representation. Scene breaks are clearly visible as are camera pans, zooms, tracking, and the difference between handheld and tripod recorded video footage. The deformation of the still image in the videogram provides a signature of camera and/or object motion as in the example above.

Audio data in the Media Time Line is represented by waveform depicting amplitude as well as pause bars depicting significant breaks in the audio. Currently our algorithm uses a set threshold which works fairly well for many videos but a more robust algorithm is needed. Significant work has been done by Barry Arons on pause detection and audio and speech parsing in general (6); we hope to incorporate these results into our system. Arons' work uses dynamic thresholding and windowing techniques to facilitate better detection of pauses in speech and the separation of speech from background noise in unstructured audio recordings. Similarly, work by Michael Hawley in developing specialised audio parsers for musical events in the audio track could be applied to automatically parsing the structure and enriching the representation of audio data (26).

In annotating the presence or absence of audio events within the data stream, our representation makes use of the fact that in thinking about audio, one thinks about the source that produced the audio. Icons for different objects and characters are compounded with the icon for the action of producing the heard sound in order to annotate audio events. This concept correlates to Christian Metz's notion of "aural objects" (32).

Annotation of video content in a Media Time Line is a simple process of dropping down iconic descriptors from the Icon Space onto the Media Time Line. Frame regions are then created which may extend to the end of the current scene or to the end of the entire movie. The select bar specifies the current position in a movie and displays the icons that are valid at that point in time. Icons are "good-till-cancelled" when they are dropped onto the Media Time Line. The user can specify the end points of frame regions by dragging off an icon and can adjust the starting and ending points of frame regions by means of dragging the cursor. A description is built up by drop-

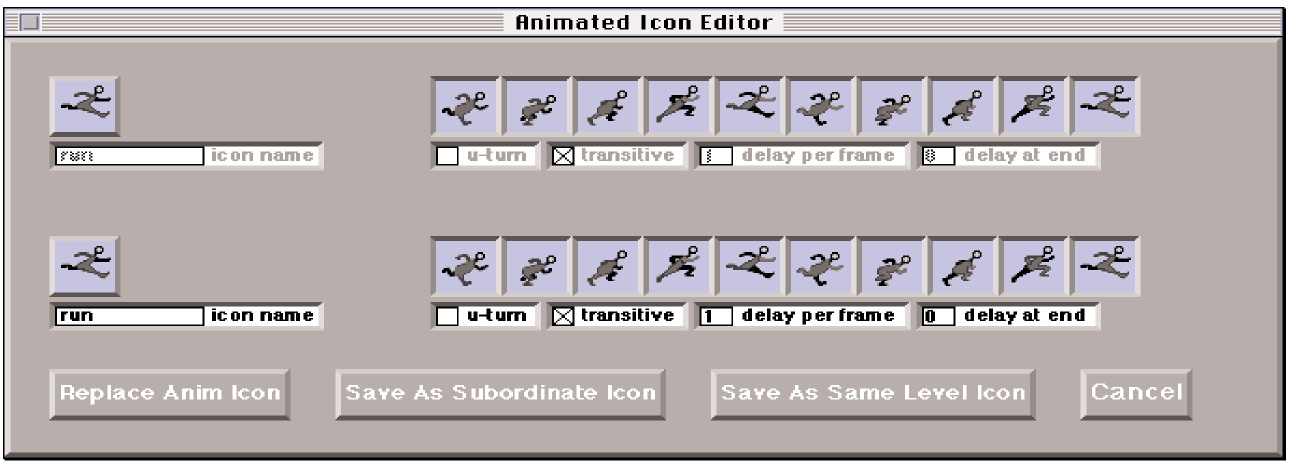


Figure 14 Animated Icon Editor

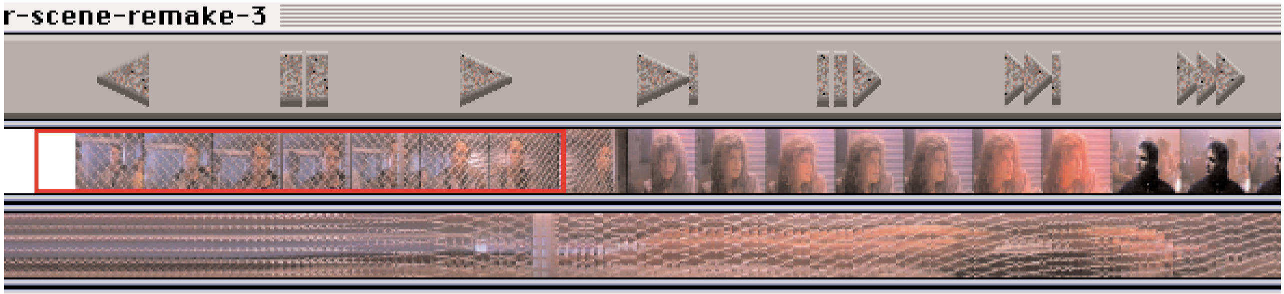


Figure 15 Media Time Line detail – video thumbnails and videogram

ping down icons for the various categories of video annotation. The granularity and specificity of the annotation are user determined.

8 Conclusions and future work

Media Streams is about to be subjected to some rigorous real-world tests. In addition to several internal projects at the MIT Media Laboratory which will be building other systems on top of Media Streams, external projects involving large archives of news footage will be exploring using Media Streams for video annotation and retrieval. Clearly these internal and external projects will teach us much about the claim made in this paper: that an iconic visual language for video annotation and retrieval can support the creation of a stream-based, reusable, global archive of digital video. We believe that this goal articulates an important challenge and opportunity for visual languages in the 1990's (23).

Acknowledgements

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SCREAM: Screen-based navigation in voice messages

BY HÅKON W LIE, PER E DYBVIK, AND JAN RYGH

681.327.12

Abstract

The bitmapped colour screens commonly found on desktops is a powerful visualisation medium. The telephone, another common desktop apparatus, is on the other hand not very visual. New services offered through the phone system can benefit from using the visualisation power of the computer display. The SCREAM project creates a visual environment for navigating the data space of voice messages. Incoming voice messages are analysed, certain caller characteristics are extracted (e.g. gender), and the system renders and displays images that help the recipient navigate the messages. This paper was presented at the 1993 IEEE Symposium on Visual Languages, August 25–27, Bergen, Norway.

1 Motivation

Networked computers have become an important medium for message handling. In many environments, text-based electronic mail is the primary choice for personal and group communication. Still, the telephone has a larger installed base, and will continue to be a part of our lives together with answering machines and voice mail systems. There are several reasons why a tighter integration between voice message systems and screen-based messaging systems are beneficial (6)(8)(9)(11). Having to check several mailboxes is inefficient, and the interface bandwidth of a touch-tone phone is limited. Sound is linear by nature and takes time to listen to, while a visual environment instantly can provide both overview of a number of items and more detailed information about a single item.

Today's personal workstations often include a high-resolution colour display which can be used to ease the navigation in the data space of voice messages. The goal of the SCREAM project is to create a rich visual environment for navigating voice messages. The recipient is presented with images that each represents a voice message, and together provide overview for selecting and sorting (i.e. navigating) messages.

The SCREAM project borrows its name from the work of art by Edvard Munch which, to most people, expresses an intense, high-pitched, hysterical scream from a female voice (figure 1). This is a highly advanced visualisation of an aural message, and – if presented to you by your answering machine – expresses several characteristics of the caller: it's a woman, she's screaming, and in a difficult emotional state.

In addition to gender and emotional state, the age, language, and accent are useful *caller characteristics*[1]. The hypothesis of the SCREAM project is that these properties, if attractively conveyed to the recipient, will improve navigation in the data space of voice messages. One example: The authors know very few Swedish-speaking children, and if a message from a Swedish child comes in, we could make a good guess at the identity of the caller and perhaps the context of the message. There would be good reasons for treating that message different from a hysterical male Norwegian with a west-coast accent – of which we know many.

Figure 2 outlines the main modules of SCREAM and the data flow between them. The rest of this paper will describe the process in more detail. Also, the user interface of the application will be discussed.

Figure 1 Edvard Munch's Scream *is the ultimate visualisation of an aural message*

2 Speech analysis

Speech can be analysed at different levels of abstractions. An audio signal – normally presented as a *wave form* (figure 3a) can be transformed into the frequency domain and presented as a *spectrogram* (figure 3b). The spectrogram indicates how much energy the signal contains in the various frequencies as a function of time. The energy of an audio signal is perceived as loudness.

Voiced speech (speech is "voiced" if the vocal cords are vibrating) consists of energy in a fundamental frequency and frequencies that are whole-number multiples of the fundamental frequency (3)(7). The fundamental frequency corresponds closely to the perceived pitch of speech. Typically, the pitch varies as one speaks – if not it's *monotone.* The fundamental frequency does not exist in unvoiced speech, and is even hard to detect in voiced speech (that is, for a machine).

Climbing the ladder of abstractions, speech recognition systems analyse the audio signal and output the textual representation of the utterance. Current speech recognition systems have limitations. Recognising a small number of isolated words spoken by one person is within reach of technology, but error rates go up as the number of speakers and words increase. Also, continuous speech is harder to recognise than discrete speech.

There is an unfilled gap between spectrograms and the textual representation, and this is where SCREAM finds its niche. Instead of just displaying a spectrogram, we try to elevate the visualisation by creating images that are more useful in a message context.

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[1] *The name of the caller is intentionally left out from this list. One of the self-inflicted constraints of the project is that the voice message itself is the only data available for creating the visual environment. Displaying the picture or name of the caller would require knowing the identity of the caller and a picture/name database of potential callers. This may be technically possible, but beyond the scope of the project.*

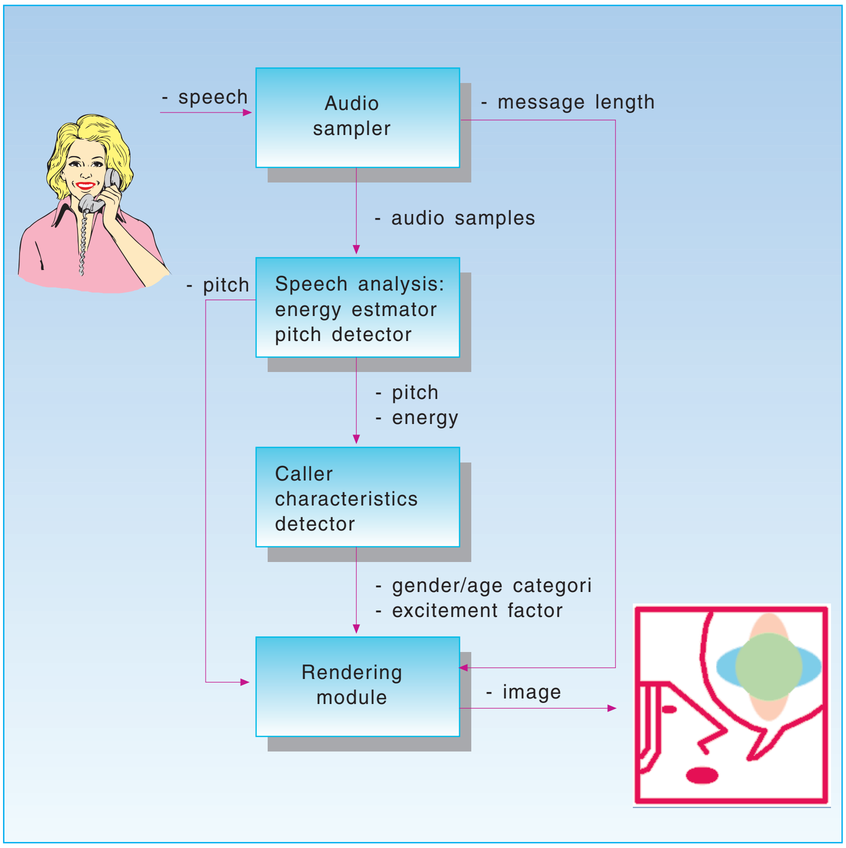

Figure 2 The main modules and data flow of the SCREAM software

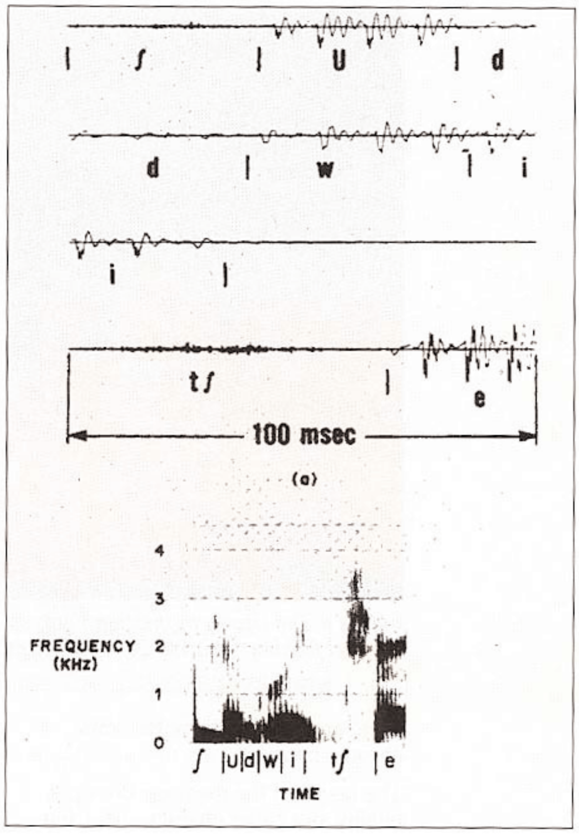

Figure 3 (a) Wave form of the utterance "Should we chase"; (b) corresponding spectrogram; from (5)

The first step in creating this process is to do a simple analysis of the speech signal. The results, which are passed onto the *caller characteristics* module are:

- the fundamental frequency of the audio signal
- the probability of having a fundamental frequency
- the energy of the audio signal.

3 Caller characteristics

Without knowing the identity of the caller, humans can determine, fairly accurately, a number of *caller characteristics* from listening to a voice message, e.g.:

- gender
- age
- emotional state
- language
- accent.

For a machine, the easier one to guess is probably gender/age, i.e. categorising the caller as *man, woman* or *child.* The fundamental frequency identifies these groups: male voices average around 100 Hz, while the same numbers for women and children are 200 Hz and 300 Hz, respectively.

The emotional state of the sender is hard for a computer to detect. However, monotone speech is often perceived as sad, while the pitch of the excited caller typically will vary (1). The same is assumed to be true for the energy of the audio signal. Calculating the excitement factor from these variations is then straightforward.

We have not tried to determine the language or accent of the caller.

4 Rendering images

What does sound look like? The question is rhetorical and no final answer can be given. However, there have been highly successful attempts to visualise sound. Munch's *Scream* has been mentioned, and the Disney animation *Fantasia* visualises pieces of music (figure 4). These are both works of art – a clear indication of where one is heading when rendering images depicting messages.

Some words exhibit relationships between the visual and aural. A voice can be described as "dark" or "light", and a colour can also be "dark" or "light". The same phenomenon is found in languages other than English. Therefore, it is natural to choose a light colour as basis when the caller is a child. Consequently, the female voice is depicted using a darker colour, while the male voice is the darkest. It may also be useful to the recipient to see variations within each category – a bass voice e.g. looks darker than a tenor.

The *excitement* factor is a little harder to visualise, but language may once again give us hints. The term *colourful* can mean *full of variety or interest*. As described above, the excitement is calculated from the variations in the pitch and energy of the audio signal. Following this reasoning, colourful images should depict messages with a high excitement factor, while monotone

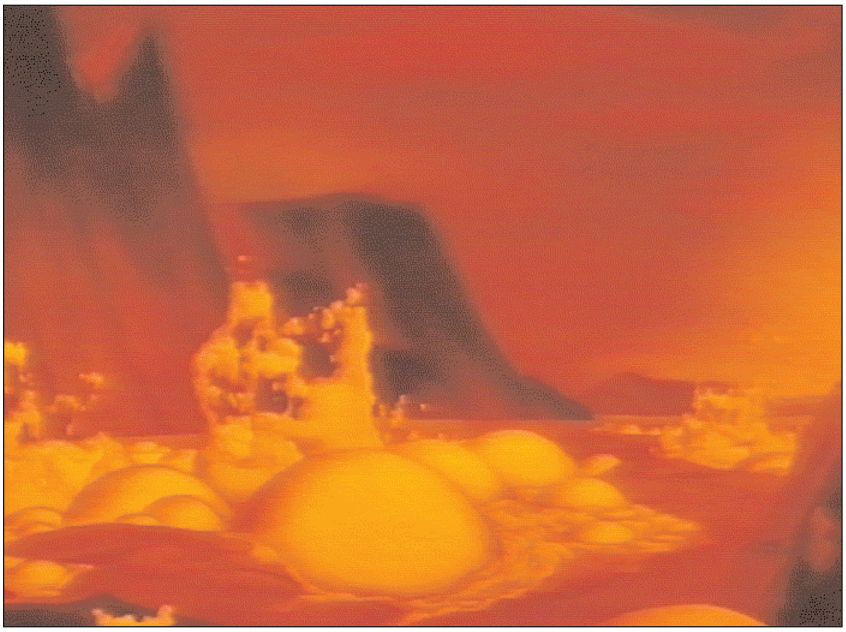

Figure 4 The Disney animation Fantasia *visualises pieces of music in a semi-abstract fashion. This image depicts Stravinsky's* The rite of spring

5 User navigation

The SCREAM project started out as an attempt to add another entry point to a multimedia mail system. The goal was to integrate the presentation of messages of different media into one coherent interface. The problem has since been simplified to only present voice messages.

Auditive user interfaces found in most voice mail systems organise messages in linear or hierarchical structures. The user must build a quite complex mental model to get the overview of available messages.

Bitmapped colour displays allow us to create a simpler model and give the user an instant overview of all messages. Images, each representing a message, are organised in an orderly manner, and provide users with direct access to the message of interest (figure 6). With limited interaction, users can navigate a large number of messages, and by clicking an image the corresponding sound file is played. The messages may be organised in several ways to fit the user's preferences using incoming time, priority, caller characteristics and length as sorting criteria.

The analysis and rendering mechanisms focus on creating one image that represents the whole message. Due to this, the project has concentrated on creating tools for navigating a number of messages instead of navigating within one message. The only element that resembles the time axis is a simple scroll bar that indicates time left when a message is played.

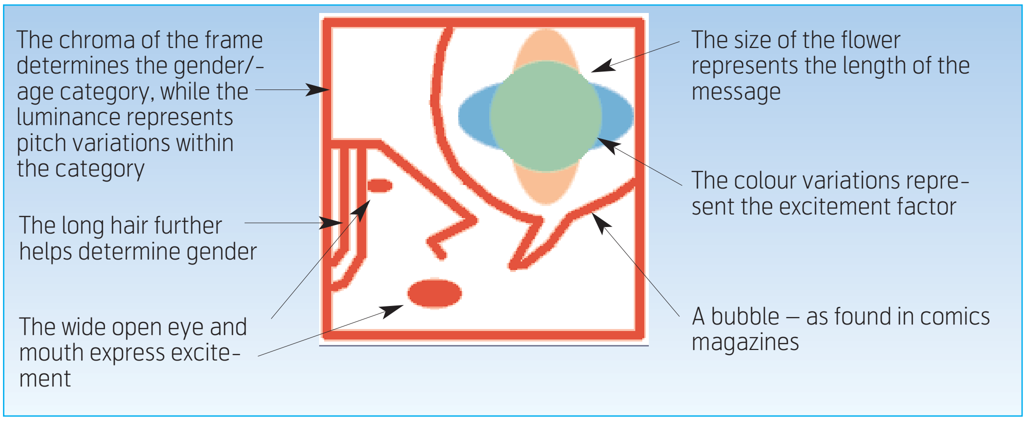

Figure 5 The rendered image conveys caller characteristics through the use of chroma, luminance, shape, and size. As with face-to-face communication, some information is redundant

6 Future work

Some of the areas where we plan to focus our attention are:

- Interesting work has been done in the area of automatic *emphasis detection* (4)(2). By visualising emphasis, the recipient would better be able to navigate within a message.
- The images that are currently being rendered do not exhibit the artistic sophistication of our inspiration. The computer may never rival Munch, but improving our methods of rendering is certainly a priority.
- Dream analysis and the vocabulary of music are also candidates for future studies.
- Currently, the SCREAM environment only renders still images. Animation may better visualise temporal aspects of a message.

We also believe that the ideas we have investigated can be useful for other applications. For example, a compact disc player could improve user navigation by visualising the timbre, rhythm, and dynamics of the music.

7 Conclusion

Integrating telephones with a desktop computer has the potential of improving existent services. The SCREAM visual environment addresses the problem of navigating voice messages. By representing each message with an image that exhibits caller characteristics, we convey information to give the user an overview of current messages as well as more detailed information about each message.

The images representing messages borrow features from common associations between sound and images. The strength of these associations have not been tested through user experiments, and surely have room for improvements. Also, one may question the correctness of strengthening the association between e.g. the colour red and the female gender.

The user interface of the SCREAM project also lacks the affirmation of formal user testing. However, judging from

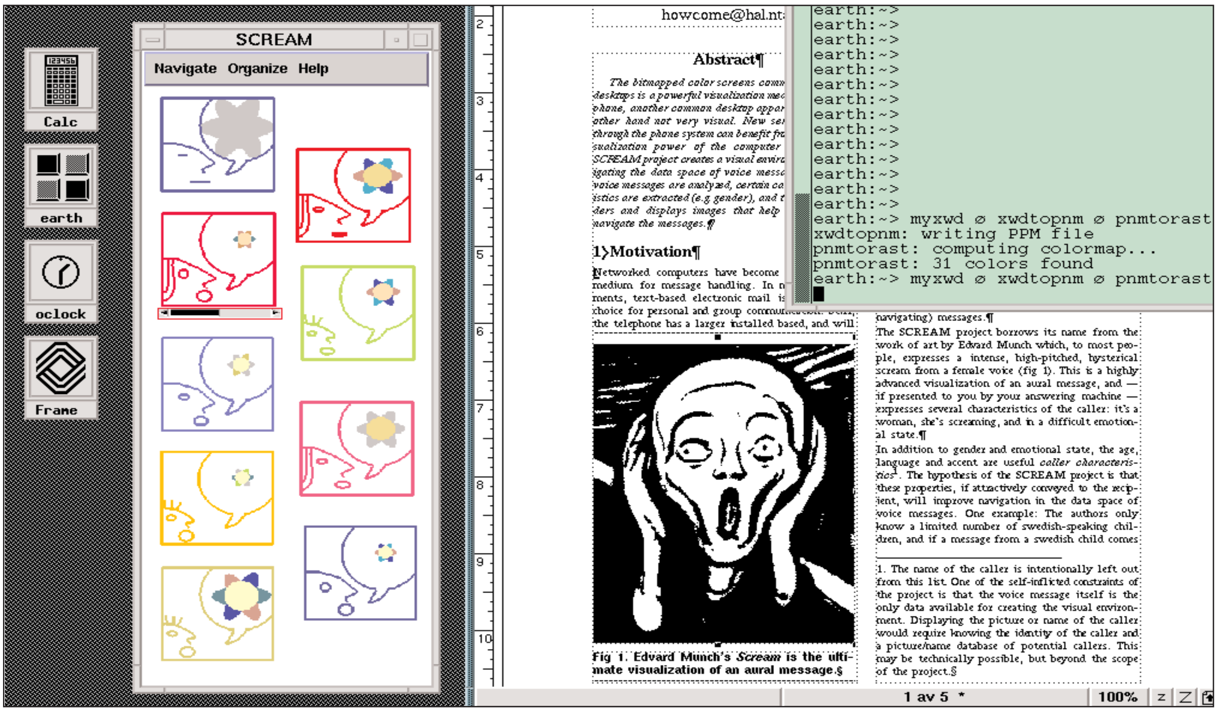

Figure 6 The figure shows a segment of one of the authors' screen while writing the paper. The SCREAM window contains messages. The uppermost (i.e. the most recent) was left by a male person with a monotone voice and a lot to say. The third message is currently being played, as can be seen from the horizontal scroll bar

using the system – and the frustration many people express when using regular voice mail systems – we believe the computer screen has the potential of becoming a preferred medium for voice message navigation.

Acknowledgements

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Telecommunications and social interaction
– Social constructions in virtual space

BY OLA ØDEGÅRD

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Abstract

This article focuses on aspects of social interaction in three categories of networked applications: computer mediated communication, networked multimedia applications and distributed virtual reality (VR) systems. Special interest will be paid to illustrate how the three different media offer various conditions for social interaction in education and work.

Introduction

Starting with the introduction of the telegraph some 150 years ago and the telephone some decades later, there has been a continuous development in two-way communication technologies. For a long time the telephone was reserved for businesses and a few households, but today 97 % of Norwegian households are connected to the public telephone network. During the last decade there has been an enormous increase in the use of communication technology, especially in telephony, but also in data communication – this includes fax and the use of modems. There has been a relative volume increase in the use of telephone network communication in Norway of about 10 % per year. This may be described as a quiet revolution.

At the same time there has been a vast spread of digital computer networks – local area networks (LAN) in organisations and wide area networks (WAN) nationally and internationally. One of the largest international computer networks is the Internet. By August 1993 more than 1.7 million computers (hosts) in more than 50 countries were connected, and it is estimated that 30 million people have access to Internet world-wide (qualified guessing by Internet Society, August 1993). Internet electronic mail connectivity stretches to 127 countries around the world, and Internet is now being made available to commercial organisations as well. It has also become more common to use the telephone network to access computer networks. The different networks offer a variety of services, from fax and electronic mail to broadband video conferencing. There is a tendency towards greater integration between the telephone network and the computer networks.

Communication technology and social settings

Today, people spend more time using communication technology than they did twenty years ago. One hypothesis is that people spend more time on their own with their terminals, and less time in face-to-face interaction with other people. This is what happened when television was introduced. The study of the social aspects of technology has often regarded technology as instrumental. This means the use of technology is directed to the achievement of specific results. That is why interaction between users through computers or the telecom network may be described as an instrumental mode of communication (Rasmussen, 1990). It has also been an assumption that interaction with less face-to-face contact between transmitter and receiver renders less social information. The research in the use of telecommunication services has shown that this is not the case. On the contrary, it seems that new communication technologies and services can be regarded as expressive media and be a substitute for and an extension to human-to-human communication in an expressive mode. Access to networks and the use of communication technology is getting increasingly important for people in their personal development as social beings, in attaining their education, and doing their work (Ødegård, 1992).

This paper will first elaborate on how social interaction is established and maintained in different networked applications. Secondly, it will look into how networked applications reflect and support social interaction. This will be exemplified through three types of applications for networked education: computer mediated communication[1], multimedia applications, and virtual reality. These offer different conditions for social interaction.

Reflection: the users in the medium

In all social interaction it is necessary to find out "who are we talking with", and how to relate in a particular social setting. To a certain extent people have learned to relate to other people and social systems through electronic two-way media. Using distributed communication technology, people can interact without being in the same place or in the same time. As people start to use different media they must develop conventions, etiquette and norms for behaviour or apply *a priori* social knowledge on how to interact with each other. We apply sets of roles and social conventions that are common knowledge to the other participants within the social interaction process. The common knowledge refers to culture in its broad sense.

Communication technology as a social medium has to support social roles for the users, and it must be easy and intuitive to establish these roles. To make this process easier, the social settings must be reflected in the application of the communication service. A newly published survey concluded that the computer as such was neutral with regard to gender – it is no more masculine than feminine. But networked applications in dedicated areas should not be neutral with regard to role definitions (who is the teacher and who is the student?). In social interaction between people who are present in the same room, the participants get the role information from the setting. If we enter a classroom as students, we know how to behave from the physical/social setting. Any deviant behaviour will most likely be met with social sanctions (Reid, 1991). Advanced and complex networked applications will improve if the medium provides users with various kinds of feedback on social behaviour.

Metaphors: the social aspects are crucial in the diffusion process

It is interesting to see how users adapt to the possibilities and limitations of new applications – especially when they cannot apply *a priori* common knowledge. In my opinion this is a crucial aspect of the diffusion of new applications and services. Or, in other words, how much concern does the network or service supplier have for the social aspects of his service. Our work has shown that in distance education, using picture communication, the teacher will experience new pedagogical possibilities through the media – possibilities he does not have in a traditional classroom (Kristiansen, 1993).

New networked applications tend to have a complex structure and difficult user

[1] *In this context, Computer Mediated Communication refers to **textual** application only.*

interface. What the application does for the users is sometimes not intuitively understandable. Therefore, it becomes even more important for the application provider to introduce to the application a metaphor that users can relate to. The metaphor must aim directly at the right users or market segment, and must be an indicator for the appropriate social settings.

It is crucial that information about social settings is mediated between users in the networked applications. Also, it is important that this information is integrated into the structure of the application and reflected at the users. This development process between technology and users may be described as a "seamless web" (Hughes, 1983), where it is no longer possible to claim technological determinism or use causal rationalism to explain the development.

The application has to support social roles of the users; to a certain extent these roles must be implemented in software and hardware. The use of an application will also depend on an adequate metaphor of the social setting. These factors have proved to be crucial in the diffusion process of the specific communication technology.

In new networked applications a "user space" is created in which the users are offered certain degrees of freedom that can and should be exploited. This space may be called a "virtual space" which can be both individual and shared (see figure 1).

On the following pages three different types of applications for communication will be introduced to exemplify how this virtual space may contain various social settings for users. The applications are: Computer mediated communication (CMC) with strict restrictions on interaction; multimedia applications using picture, sound, and text for communication; and distributed virtual reality (VR), which puts the users into an immersive computer-generated environment.

CMC: Computer networks and social networks

In computer mediated communication (CMC), written text is mediating messages and codes. CMC can be described by two interesting characteristics (Kiesler, 1984):

1. We lack information about the social context of the communication process. There are few indications on the social status of the users. In many applications it is possible to remain anonymous.
2. We lack accepted norms for the use of new media. The conventions for behaviour and the possibilities for giving feedback may be limited in new applications.

There are obvious limitations in CMC compared to face-to-face communication. In face-to-face communication, indicators like body language, dialect and clothing inform us of what social setting we are encountering. It has to be noted that the two above mentioned characteristics were formulated in 1984, and that is a long time ago in the history of electronic communication. Today, manuals and user guides for applications on the Internet contain guides on etiquette. There are examples of etiquette for users in News at Internet (Ness, 1992):

- Be proud of the message (article) you transmit, never send anything you will regret later.
- Do not answer a message in anger! If you are provoked, stay cool a few hours before you answer.
- Let the accused receive the benefit of the doubt! Read the message at least twice, and be generous in your interpretations.
- Be fair and polite! Never write anything you would not say to the recipient in a face-to-face situation with other people present.

To break the accepted norms for behaviour causes anger, and system managers can expel the author from the system. *Flaming* (using abusive language) and pretending to be of the opposite gender are examples of unacceptable behaviour in some social electronic cultures. Building friendships through electronic media involves trust and confidence, and committing forgery is met with sanctions.

Several research projects (Reid, 1991) have shown that users of electronic Bulletin Board Systems (BBS), computer conferences and different news groups on Internet tend to build social networks. People with special interests get acquainted and develop friendships, and romances also appear. People have married after becoming acquainted through the network. There is also a very important democratic element in the use of

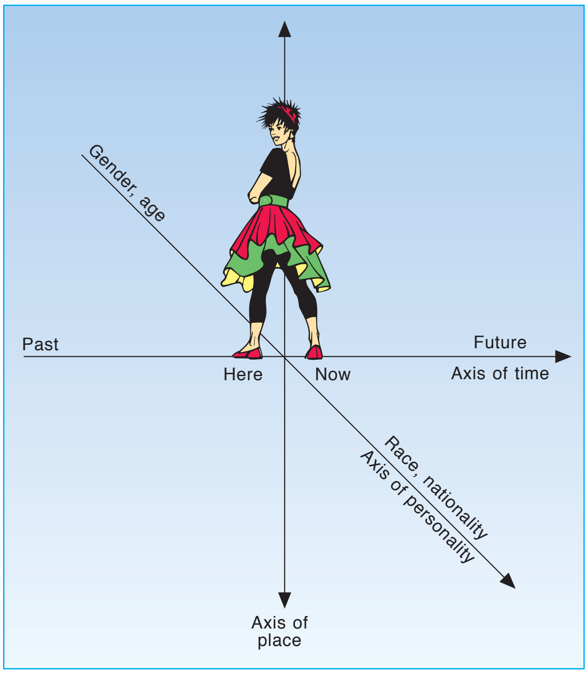

Figure 1 The different mediated applications are first of all independent with regard to time and place (axis of time and axis of place). Secondly, they can offer varied personal freedom with regard to interpretation of personality, gender, race, or nationality

electronic media. In theory, anybody can address anybody regardless of age, sex, race, nationality and social status.

Pre-existing social networks are no prerequisite for the establishment of electronically based social networks. In fact, it may be an advantage for the development of an electronically based social system that the participants have never met. Then they will have the best conditions for developing their own "culture", which consists of a set of norms and values that are internalised in a group of people that use this set of norms to solve problems. This is done through development of a set of symbols and a literate form of expression that exceeds the limitations of the medium. One example of this is the *emoicons*. They were first introduced by Scott Fahlman in 1980 on a BBS (Reid, 1991). A few of them are quite common in electronic mail, BBS and CMC today, but in some electronic "societies" over one hundred have been discovered. Here are some examples and their meaning (Godin, 1993):

:-)	A basic smile
:)	A midget smile
;-)	A smiling face winking an eye
:-X	A big wet kiss
@:-)	Smile wearing a turban

:-(	A sour face
:-(*)	Feeling sick
:-P	Pointing the tongue
:-&	Can keep a secret
:-O	A scream
=8-(	Horrified face with wide open eyes
:-/	Making faces
@}--\------,---	A rose, token of love
<i>	Irony

Successful and meaningful electronic interaction is often reliant on the use of such symbols in order to verbalise actions and emotions. It is important for participants to master this kind of symbolic language.

Applications for distance eduction

In distance education, computer mediated communication (CMC) has been in use for a decade. During the last years there has been an increase in the demand for flexible learning, life long learning, on the job training and retraining of the unemployed. Distance education using CMC has in many cases proved to be efficient.

The notion of a *virtual classroom* has been widely spread as a metaphor of a real school with all the familiar facilities (see figure 2). The virtual classroom functions as an interactive learning space with many promising dimensions. One aspect is how CMC can support group work (Kaye, 1992). Group work involves reflection, decision-making, and problem-solving and has its own laws of energy: it consistently yields results of a higher calibre than those attained by the average group member (Hiltz, 1982). Not only can group work improve, but also the individuals learn more than those of comparable skills working alone. The combination of social osmosis, the circulation of ideas, and the links established among the participants all contribute to increase the efficiency of CMC group exchanges (Henri, 1992).

CMC based courses for students at university level have been offered for many years. The potential in CMC has also been discovered by teachers and pupils in elementary schools.

KIDLINK: Creating the global village

As the interdependence of all the people of the world increases with regard to both culture and infrastructure, the KIDLINK project is trying to create a global village by linking the youth of the world in an electronic dialogue. In 1993, 10,000 children from fifty countries joined KIDLINK (Stefánsdóttir, 1993). KIDLINK is based on list servers and electronic mail. In its simplest form, the dialogue is an exchange of personal presentations and views on the desired future of this world. KIDLINK uses a school building with many rooms as metaphor. Each mailing list is similar to a room with a special activity; some are for students and some for teachers. Every room has a moderator, responsible for the ongoing activities.

One room is just for announcements. It gives newsletters and media reports. In another room users can (and must) introduce themselves, and they can search for friends in KIDCAFE. One of the purposes of KIDLINK is to cultivate a better understanding between students from different countries and cultures. KIDLINK gives them the feeling that they all participate in the same “global classroom”. The fact that they have to make presentations and form their own identity in the system also gives them social training. On one occasion participants in KIDLINK had a computer based chat with a polar expedition team walking across the Antarctic. Another project involved the vast economic deficit of the United States. The action caught the eye of president Clinton, who sent them a message back through a KIDLINK list. Each year in May, at the conclusion of the projects, all students are invited to a “chat” (asynchronous dialogue), with each other in a global dialogue.

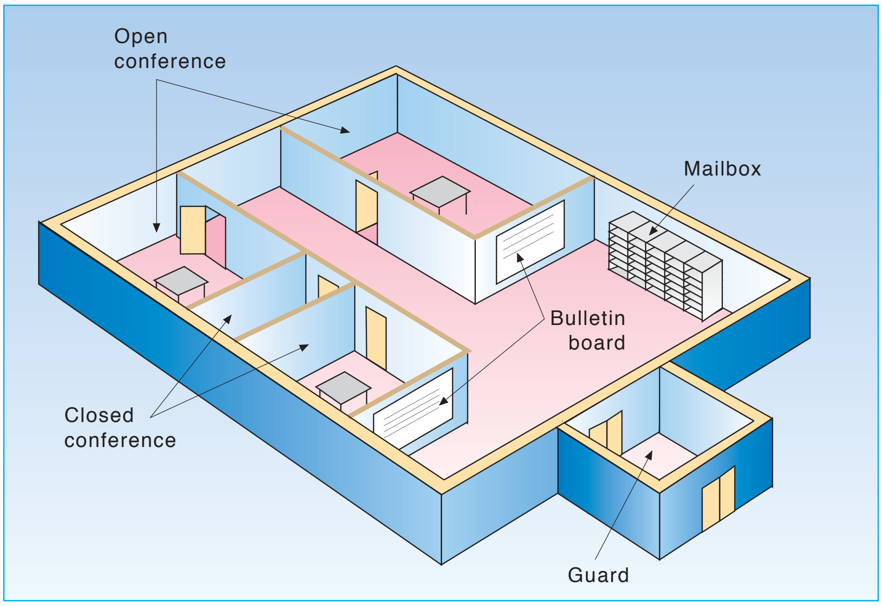

Figure 2 The virtual classroom is a frequently used metaphor in computer conferencing systems for distance education

The Planet project

The Planet project is another example of how students can make use of CMC in education. It involves children between the age of 9 and 18 from schools in eight European countries. The Planet project is based on electronic mail centred around an imaginary planet X. The project allows children to become space voyagers who travel to and settle on Planet X. The project is classroom based where the whole class participates. Each student must be given a new name, age and position in the spacecraft. The project emphasises the group work of the children. They have to decide on what mission they have at Planet X, what their spacecraft consists of, language and culture. They invent what they find: topography and mythology. Once they have landed, the children share experiences, problems and decisions which will affect the whole planet with voyagers from other schools via electronic mail. The planet has a history: students may receive direct messages from other explorers who have already visisted their sector at Planet X.

The project appeals very much to the students' imagination and spontaneity (Clifford, 1993). They are confronted with the choices they have made earlier, e.g. on the goal of their mission and the use of weapons. The participants take part in the creation of a planetary society where imaginary role-play is important.

Both the KIDLINK and the Planet project are examples of how applications using computer mediated communication can support educational purposes. By giving the participants (users) access to an electronic virtual world, they can take part in social interaction and develop as social beings.

KIDLINK and the Planet project are good examples of how networked applications for education can support collaborative learning, group work, and personal development, creativity, responsibility, etc. The virtual classroom metaphor is given content by the users. Both applications are reliant on organisational support from teachers and moderators. CMC is limited in being text based, but proves to be sufficient in many social settings. Ten years of experience with CMC have shown that "just" text based communication can support great virtual worlds and complex social settings.

Multimedia

Teleproff, a workstation for distance education

A workstation for distance education, developed by Norwegian Telecom Research and their industry partner NovaKom, is an example of how one can utilise multimedia technology which integrates computer based communication with video and audio communication (figure 4). The Teleproff workstation is based on the video codec from Tandberg Telecom for ISDN. One workstation is placed at each end, and when the ISDN connection has been established, the system must be told which station is to be the techer's and which is to be in the classroom. The teacher can then control all external and internal media sources in an MS-Windows based environment. The workstation consists of a PC, a camera pointed at the teacher, a document camera for slides, overheads or objects. It is integrated with the use of ready made image files, so that the teacher can produce course material in advance and open it as files. The participants in the remote classroom are represented as icons and video images in the workstation of the teacher. The students have controlled access to the computer. Anybody with access to ISDN is a potential user of such a virtual classroom. The Teleproff workstation is under evaluation in three locations. Experiences so far seem promising with regard to the pedagogical possibilities.

Broadband multimedia: Supernett

Norwegian Telecom and Uninett (the Norwegian part of Internet) have established a trial 34 Mbit/s switched network interconnecting the four universities in Norway. The goal of the establishment of Supernett was to strengthen Norwegian Telecom's future public infrastructure to handle bandwidth-consuming applications, the academic research and education in information technology, industrial competitiveness and internationalisation. The main use of the network will be distributed multimedia applications, based on a collaborative multimedia desktop environment that supports real-time audio, video, document conferencing and distributed multi-user shared workspace (Kure, 1993).

Electronic white board

The University of Oslo (USIT/UiO), the University Centre of Technology at Kjeller (UNIK) and Norwegian Telecom Research have developed and prototyped the concept of an electronic classroom in Supernett (figure 5). In education the chalk and blackboard have for centuries been indispensable for the teacher, a function not easily emulated in electronic distance education. Many teachers feel more comfortable walking in front of the blackboard instead of using a keyboard and mouse. In this application it is important to capture and transfer both the blackboard information, and the image of the teacher. The teacher should be able to write and erase. With the use of an electronic pen and an interactive "white board" (2 by 3 metres) controlled by a computer this has been made possible. In addition to writing information on the board and erasing from it, it is possible to present electronic documents, still pictures, high resolution graphics and video. It is possible for the teacher to edit, underline, etc. in all images and text shown on the board.

The idea is that the teacher can teach a group of local students and distant students at the same time. All universities connected to Supernett can participate in the same electronic classroom. The students at the receiving location have the same type of electronic white board and a separate monitor showing the video image of the teacher. The network connection is open all the time, and this makes it possible for students to ask questions during the sessions. Today, the teacher can prepare all material and make it available through the medium. In the future, material can have hyper-structures to networked databases and conferences if the students want to explore beyond the limits of the curriculum. It will integrate electronic textbooks and encyclopeadia with links to external databases.

Figure 3 A computer conferencing system like KIDLINK can be a medium for creative young artists. The Midsummer Witch is painted by 12 year old Ida Berg Meye of Denmark

The prototype of the electronic white board is now being used on a trial basis in a university course. The project is evaluated by Norwegian Telecom Research[2]. Our experience shows that this technology can provide the teacher with the necessary tools for teaching and students can participate in classes otherwise not accessible. However, the technology does not sufficiently support interaction between teachers and learners or interaction between the two groups of students. The students in the remote studio classroom experienced a distance through the media. The audio connection is crucial, time delay and distortion are obstacles. In addition, the students are not used to be "on the air", and this makes them reserved. One consequence of this is polarisation – the quiet and modest students get even more quiet and modest through distance education technology (Kristiansen, 1993). On the other hand, the loud and dominant students get more dominant. It must, however, be noted that the students are still inexperienced and have not had the time to

Figure 4 The classroom situation using the Teleproff, ISDN workstation for distance education

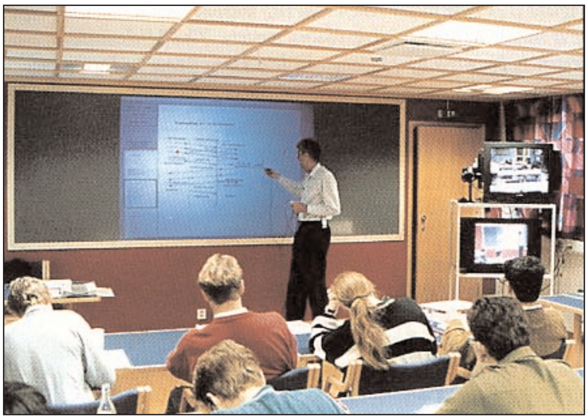

Figure 5 Using the electronic whiteboard the teacher's presentation can be displayed in several receiving classrooms

The prototype of the electronic white board is now being used on a trial basis in a university course. The project is evaluated by Norwegian Telecom Research[2]. Our experience shows that this technology can provide the teacher with the necessary tools for teaching and students can participate in classes otherwise not accessible. However, the technology does not sufficiently support interaction between teachers and learners or interaction between the two groups of students. The students in the remote studio classroom experienced a distance through the media. The audio connection is crucial, time delay and distortion are obstacles. In addition, the students are not used to be "on the air", and this makes them reserved. One consequence of this is polarisation – the quiet and modest students get even more quiet and modest through distance education technology (Kristiansen, 1993). On the other hand, the loud and dominant students get more dominant. It must, however, be noted that the students are still inexperienced and have not had the time to develop etiquette for behaviour using this media, e.g. on how to get the required attention to interrupt a session.

There has been a tendency to use the interactive white board only as a presentation tool, and not as a communication tool. It may be confusing for the students to relate to white board information in one place, and the video image of the teacher on a monitor in another place. As in other picture based distance education, it is our experience that the sound in this application is the most important source of information.

The critical point here is whether the students at the universities will "understand" and accept the limitations and possibilities in the whole concept of electronic classroom as such. The students have so far had a positive attitude towards this kind of education. They get a broader variety of courses to choose from and save travelling time.

The Teleproff Workstation for Distance Education and the Electronic White Board are examples of networked multimedia applications. The technology (hardware) is much more present and the social role setting is implemented in the equipment itself. They are based on advanced technology and are complex with regard to user interface. The role setting is intuitive, but the human-to-human communication is complicated and hard to co-ordinate for the teacher. There is a need for a new kind of teacher that must be able to be a producer, i.e. to use the different windows, pictures and information sources efficiently. At the same time the students should get into a new role. From being passive listeners, they have the possibility of using the two-way communication tool to access the source of competence and information. The critical part is on one side to make good pedagogical applications to support the teachers. On the other side, it must appeal to the students by stimulating them to exploit the media.

In multimedia installations the social roles and settings are implemented in both software and hardware. Multimedia applications are technologically more advanced than CMC. The multimedia applications described are dedicated to a specific application area. This can at the same time make them more restricted and rigid for the users to define the best way to use the application. To make good networked multimedia applications requires thorough knowledge of the social sphere which is to be covered, and this has to be the overall principle in the development process.

Networked virtual reality: virtual reality in distance education

In the last couple of years, Virtual Reality (VR) has been a buzzword in the computer industry. It has been associated with devices like head mounted displays (HMD) and data gloves which put the user into an immersive synthetic environment (figure 6). Today, we will find most of these installations in entertainment centres and video game arcades, but we are starting to see educational applications for networked immersive environments. So far, VR has been associated with purely computer generated images, but we can already see hybrid VR solutions using the immersive graphic user interface in combination with live video – e.g. in deep sea operations or in education (Øderud, 1991). VR has a definite potential outside entertainment.

One hybrid VR application for education is the *Virtual Cities* (Stanfel, 1993) project by the National Film Board of Canada in co-operation with the Toronto-based Vivid Group and Telsat Canada (figure 7). More than ten international satellite and telecommunications organisations joined forces to carry out a virtual reality satellite teleconference live to audiences on five continents. The children (aged 12 to 17) participating in the Virtual Cities demonstration were located in electronic classrooms in Ottawa (Canada), Florida (USA), and Lecce (Italy). A visual database, composed of images recorded by students and enhanced with film footage was overlaid with instructional gaming strategies, to provide the students with opportunities to explore and simlate the evolutionary development of urban space. Layering video footage, interactive computer graphics and digitised images of the

[2] The Electronic Whiteboard is still under evaluation by Tove Kristiansen and Ola Ødegård at Norwegian Telecom Research.

children themselves, Virtual Cities creates a dynamic media environment within which the real environment can be studied and understood from a new perspective. The application does not require head mounted display or a data glove, just an inquiring mind and the desire to explore new worlds. The Mandala System from the Vivid Group is based on Myron Krueger's CRITTER concept, which allows the user to interact with virtual objects or virtual persons, like playing music within the virtual world simply by touching objects displayed on the video monitor. It is all done by physical motion, without any input device other than video camera.

The Virtual Cities project is dependent on active participants in all locations. The students use many aspects of themselves. The illusion of their bodies is put in an immersive environment and they are interacting through speech and vision and body language. Simultaneously, the participants can "go" through the same experiences and in the same place. This gives them a unique possibility to create a common understanding and insight into each others' lives and cultures. The children in the Virtual Cities project had the illusion of being in the same space, in total interaction even with body language. Their global interacting was a great experience for them.

The objective of the project from a pedagogical point of view is to increase emphasis on environmental issues and the management of the world resources. The students will come to understand the global picture of human interdependence on natural ecosystems, and the impact on those systems in the context of their own backyard. By making presentations of their own region in a VR environment, the other students can comment and manipulate the shared image.

There have also been trials connecting VR applications through the ordinary telephone network. In 1992, Carl Loeffler conducted a technical demonstration between Carnegie Mellon University and the EXPEDITION 92 conference in Munich, Germany. Users at the participating sites had independent viewpoints and the ability to move objects within a shared immersive environment; a Networked Art Museum (Loeffler, 1992) (see figure 8).

Being networked makes it possible for participants in different locations to "enter" the same virtual space and interact socially with each other. Virtual reality may change the way we communicate and the way we learn (Søby, 1993).

Conclusions

Televirtuality: a space for personal expression

In the first part of this article the importance of factors like metaphors in the diffusion of networked applications was pointed out. The recognition of how users apply social information and sets of roles in their interaction through different media has in many cases been neglected by the application providers. To support social interaction like education through electronic media, it is crucial that the social information, the roles, and the pedagogics are reflected in the application and the technology. This is a long development process in which both technologists and social scientists have to take part. In distance education it is the learning process through media that is interesting, and not technology itself. To apply insight into the social processes has to be a fundamental part of designing functioning networked applications.

Three networked media

One tentative ambition of this article has been to show how three different media – computer mediated communication, networked multimedia installations, and networked virtual reality – have similarities and differences with regard to social interaction and how this is supported in the technology. CMC applications have been in use for more than ten years. The users' ability to express themselves and communicate through a medium primarily based on text has proved to be vivid and well suited for the purpose. As shown in this article, the social interaction between users in CMC applications are regulated through etiquette and shared information for behaviour. At the same time the technological possibilities for the mediation of social control and social information are restricted.

Multimedia has other requirements with regard to equipment as well as other

Figure 6 The head mounted display (HMD) with stereo vision and sound puts the user in an immersive environment. A dataglove and a head tracker system for positioning can be used for interaction with other users/objects in a networked virtual reality

requirements and possibilities for the users. Social control through picture communication may be present. Social interaction can take place at a higher level than CMC. For some users this will be a limiting factor for personal expression. It is therefore reason to believe that multimedia applications will more easily adopt norms for behaviour, or interaction that are similar to face-to-face interaction.

Currently, we are only seeing the beginning of networked virtual reality systems. We do not have much experience and field research with VR. Virtual Reality teleconferences used for education and work are expected. So far, the systems have been too expensive and the computer generated environments have been of too poor quality (Lie, 1992). The experiences indicate that VR will become a powerful medium for pedagogical and teleconfe-

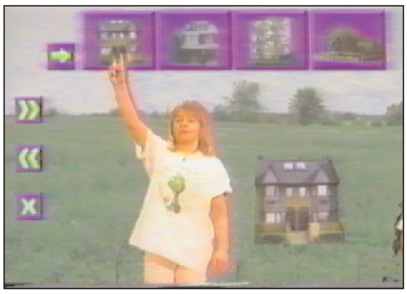

Figure 7 Using the Mandala system the user's body is projected into a virtual world in which she can interact

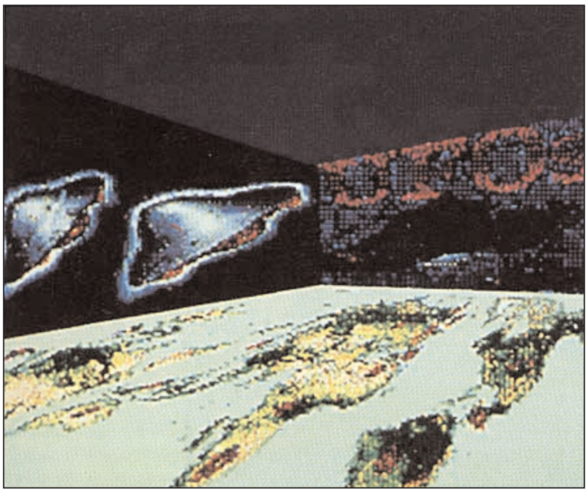

Figure 8 Within the Networked Art Museum it is possible for the users to attach an UFO and fly around the world in it

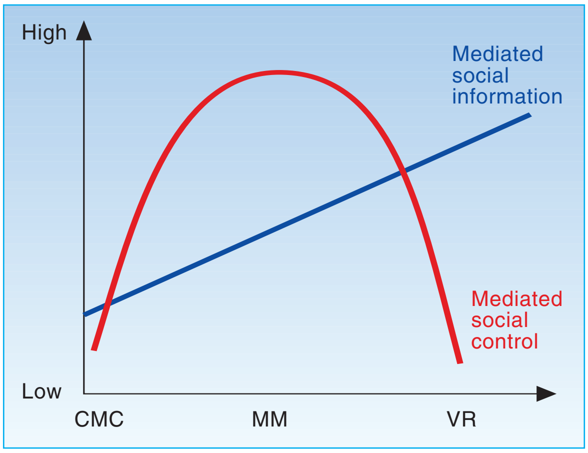

Figure 9 Computer Mediated Communication (CMC), MultiMedia applications (MM) and Networked Virtual Reality Systems (VR) offer various possibilities and limitations for the users to mediate social information and social control

rence applications. The medium offers possibilities for visualising objects and characters in three dimensions and at the same time lets the users interact inside the application. This makes it easier for users to comprehend complex structures. In addition, it is possible for the users to develop the application or objects in the application while they are in it. In networked VR applications, the users will experience a stronger degree of personal expression than in the other media. The social information mediated through the application will most likely be rich, but as a result of the possibilities of personal expression, social control may be limited (see diagram in in figure 9).

The challenge for designers of networked applications is to make use of the experience gained from ten years of research on social aspects of networked applications. This research has amplified the social constructions created in networked virtual space. In VR applications, life-like elements like gravity have to be reinvented. The next challenge is to recreate symbols of culture, and norm and etiquette for social interaction. It is easy to see that the contribution from CAD programmers and graphics designers is not sufficient in the development process of socially stimulating virtual worlds.

All interactive media will have an effect on the users' perceptions of selves. But it is expected that distributed virtual reality systems will do this to a further extent through increased flexibility in mediated human-to-human communication compared with other media.

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Distributed Virtual Reality:
applications for education, entertainment and industry

BY CARL E LOEFFLER

654.1:681.3

Case was twenty-four. At twenty-two, he'd been a cowboy, a rustler, one of the best in the Sprawl. He'd been trained by the best ... He'd operated on an almost permanent adrenaline high, a byproduct of youth and proficiency, jacked into a custom cyberspace deck that projected his disembodied consciousness into the consensual hallucination that was the matrix.

William Gibson,
Neuromancer,
1984 (1)

Cyberspace is a globally networked, computer sustained, computer generated, multi-dimensional, artificial, or virtual reality. In this world, onto which every computer screen is a window, actual, geographical distance is irrelevant. Objects seen or heard are neither physical, nor, necessarily, representations of physical objects, but are rather – in form, character, and action – made up of data, of pure information. This information is derived in part from the operations of the natural, physical world, but is derived primarily from the immense traffic of symbolic information, images, sounds, and people, that constitute human enterprise in science, art, business, and culture.

Michael Benedikt,
Collected Cyberspace Abstracts,
1990 (2)

We foresee that computing environments in the next decade will be very widely distributed, ubiquitous, open-ended, and ever changing. All the computers in the world will be mutually connected. New services will be added from time to time, while old services will be replaced. New computers will be connected, and the network topology and capacity will be changing almost continually. Users will demand the same interface to the environment regardless of login sites. Users will move with computers and will move even while using them. Users will also demand much better user interfaces, so that they will be able to communicate with computers as if they are communicating with humans.

Mario Tokoro,
Toward Computing
Systems for the 2000's,
1991(3)

Abstract

This text addresses virtual reality and how can it be networked to support multiple-user immersion environments, joined over long distance. The sites are networked using low band modem-to-modem over telephone lines, the Internet, and high bandwidth telecommunications. The major contribution is a discussion of the networked virtual reality projects produced at the STUDIO for Creative Inquiry, Carnegie Mellon University. The project team has designed and constructed the ***Networked Virtual Art Museum****, an art museum, which joins telecommunications and virtual reality. And, other distributed virtual reality applications, including a virtual city, a* ***Virtual Design and Teleconferencing Station****, the* ***Virtual Show Room****, and a* ***Virtual Test Track****, among other projects. The conclusion forecasts a not so distant future where education, entertainment and industry will employ networked immersion environments.*

Introduction

The promise of virtual reality has captured our imagination; networks will render it accessible. There can be little doubt that networked immersion environments, cyberspace, artificial or virtual reality, or whatever you want to call it will evolve into one of the greatest ventures to ever come forward. Virtual reality will draw from and affect the entire spectrum of culture, science, and commerce, including education, entertainment, and industry. It will be multi-national, and will introduce new hybrids of experience for which descriptors presently do not exist.

Earlier in this text, Gibson, Benedikt, and Tokoro are cited. At first reading they might appear to be divergent tracks, but welding them together contributes significantly toward the framing of a "matrix," a "computer-sustained, computer-generated, multi-dimensional, artificial, or virtual reality," that is "widely distributed, ubiquitous, open-ended, and ever changing." They also suggest three essential areas of recent cultural and technical development:

1. The formation of a cyber culture, which includes individuals who prefer to inhabit the domain of distributed digital media – electronic bulletin boards, databases, and multi-user simulation environments, including virtual reality. These inhabitants more or less live in such domains; the majority of their time is occupied within them. There they can alter their identities, their manner of social interaction, and their relationship with society. They become virtual beings in a virtual place. By living in such domains, a society becomes established, and a morality may emerge. What kind of morality will this be? Will it be governed? By whom and for what? This line of questioning becomes even more involving when one considers distributed virtual reality as a three dimensional environment, that may contain private spaces or residences, which contain personal objects and possessions.

2. The emulation of the physical world, and private spaces may have doors, closets, and windows that look out onto multi-dimensional vistas. Toolkits allow for the transformation of the world, and extensions of it are comprised of a never ending field of pure data.The field of data can include all walks of commerce and produce worlds which do not fit our present descriptors. Some experiences will be familiar, like going shopping, or going to a concert. Other things will be unusual, like going to an ancient place or another planet.

3. The pervasiveness of the data field is everywhere, and people move about with computer devices. Interfaces become intuitive. Guides or agents co-inhabit the domains. Agents acquire knowledge, become familiar, and grow old with us.

While this could read as science fiction, extensive research is already being conducted in networked or distributed virtual reality. It currently constitutes a very small industry, but one with great potential for growth. Our research in virtual reality at the STUDIO for Creative Inquiry at Carnegie Mellon University (CMU) investigates this field, and relevant applications within it.

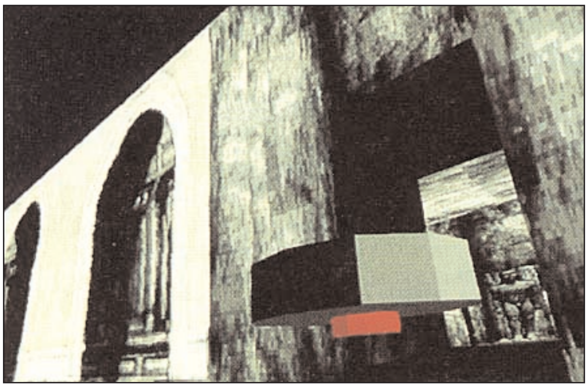


Figure 1 Outside of the networked Virtual Art Museum, which is designed to resemble the College of Fine Arts, Carnegie Mellon University. Object in front is a UFO, or flying saucer, which can be piloted by end users. Produced for Expedition 92, Germany. Designed by Carl Eugene Loeffler

Figure 2 Inside the Virtual Art Museum, complete with sculptures and galleries. Designed by Carl Eugene Loeffler

The Networked Virtual Art Museum

Perhaps it is useful to report on one project at the STUDIO in greater detail. The project is the *Networked Virtual Art Museum*, which joins telecommunications and virtual reality through the design and development of multiple-user immersion environments, networked over long distance. The essential areas investigated through the project include world-building software, visual art and architecture, telecommunications, computer programming, human interface design, and artificial intelligence, communication protocol, and cost analysis.

Visual art and architecture

The fusion of disciplines is the basis for collaborative authorship of virtual worlds. The construction of the virtual museum involves the participation of visual artists, architects, computer aided design teams, computer programmers, musicians and recording specialists as well as other disciplines.

World building

The project serves as a testing site for world building software and associated hardware (4). The programming teams have added considerably to the functions of the software tested. Public releases are in planning.

Telecommunications

Critical to the project is the development and implementation of networking approaches, including modem-to-modem, server, and high bandwidth connectivity. Telecommunications specialists collaborate with the design team to resolve problems of connectivity in immersion environments. Project achievements in this area are discussed in greater detail below.

Artificial intelligence

The application of artificial intelligence, in the form of agents (or guides) and smart objects, is an essential area of development. The inclusion of investigators in the areas of interface design, smart objects, and artificial intelligence is a major component.

Groupware and communication protocol

The project documents multi-user interaction and groupware performance, establishes protocols within networked immersion environments, and suggests standards. The contribution of communication specialists addresses aspects of documentation and standardization.

Cost analysis

Other planned study addresses the practical nature of networked immersion environments, investigates the effectiveness of information access for the end user, and profiles the end user experience. The project involves the participation of cost analysis specialists and formulates a practical cost basis for networked immersion environments.

The project team has designed and constructed a multi-national art museum in immersion based virtual reality. The construction of the museum involves a developing grid of participants located in remote geographical locations. Nodes are networked using modem-to-modem telephone lines, the Internet, and eventually high bandwidth telecommunications.

Each participating node will have the option to interact with the virtual environment and contribute to its shape and content. Participants are invited to create additions or galleries, install works, or commission researchers and artists to originate new works for the museum. Tool rooms will be available, so one can construct additional objects and functions to existing worlds, or build entire new ones. Further, guest curators will have the opportunity to organize special exhibitions, explore advanced concepts, and investigate critical theory pertaining to virtual reality and cultural expression.

The Museum

The design of the museum centers on a main lobby from which one can access adjoining wings or galleries. Several exhibitions are completed, while others are under construction. The first exhibition to be conceived and completed, is *Fun House*, based on the traditional fun house found in amusement parks. The museum also contains the *Archaeopteryx,* conceived by Fred Truck and based on the Ornithopter, a flying machine designed by Leonardo da Vinci. Imagine flying a machine designed by one of the worlds greatest inventors. The team is also collaborating with Lynn Holden, a specialist in Egyptian culture, to complete *Virtual Ancient Egypt,* an educational application based on classic temples mapped to scale. The gallery exhibitions mentioned are being constructed at CMU. However, we are anticipating other additions conceived and constructed by participating nodes in Australia, Canada, Japan, and Scandinavia.

Now that the framework of the museum project has been described, perhaps it is useful to discuss the essential points of one application.

The Fun House

Fun house: a building in an amusement park that contains various devices designed to startle or amuse.

Webster's Dictionary, 1992

For the first installation in the *Networked Virtual Art Museum,* a *Fun House* was designed. While making

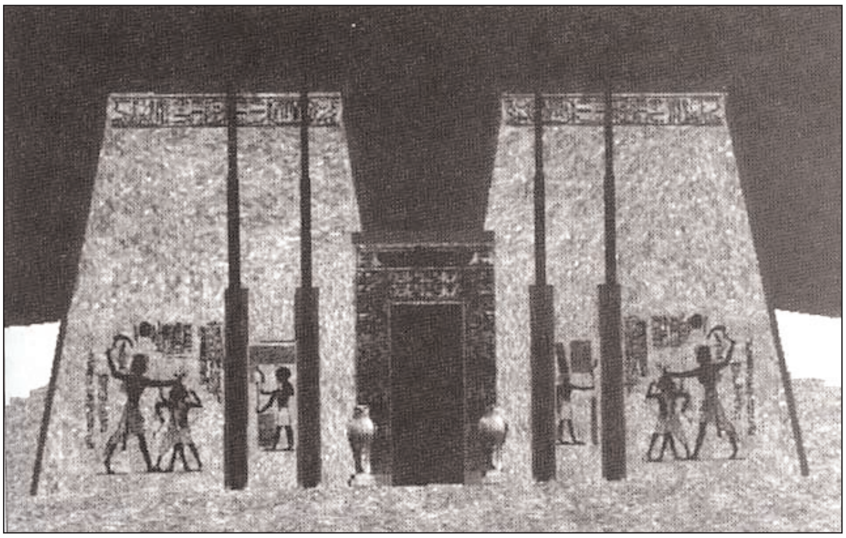


Figure 3 Outside of the Temple of Horus, from Virtual Ancient Egypt, a networked application. Produced for Intel Corporation, USA. Designed by Carl Eugene Loeffler and Lynn Holden

metaphorical reference to the "fun house" found throughout traditional amusement parks, the application is an investigation of interaction and perception employing networked, immersion based virtual reality. It was this world which was utilized during the first long range demonstration conducted between Carnegie Mellon University and Munich, Germany, in September 1992. A more recent demonstration, featuring a different virtual world, was conducted between CMU and Tokyo, sponsored by the *International Conference on Artificial Reality and Tele-existence,* July 1993, Japan.

The fun house metaphor is particularly applicable as a container for virtual experience. Upon entering a fun house, one is acutely aware of being cast into a different world. And one's senses are amused and assaulted by a number of devices – trick mirrors, fantasy characters, manipulation of gravity, spatial disorientation, mazes and sound, for example. In the virtual *Fun House,* various traditional devices are adapted and some new ones are offered.

Key attributes to be found in the *Fun House* include:

- *Objectification of "self" within an immersion environment.*
  Users can select their image from a library including Frankenstein, Dracula, and a doctor, among others – the Cookie Man has proved to be a favourite. When entering the *Fun House,* users can see their image reflected in real time in a mirror. They can also see the images of other users. Users can extend their hands and wave at each other – a basic and highly communicative form of human expression.
- *Interaction with a client (or agent) which has an "artificial intelligence."*
  When entering the *Fun House* a client greets you and speaks. It has a polite behavior and is programmed to face you, follow at a certain distance, and to stay out of your way. After a while, it stops following and says goodbye. Smart objects are also incorporated; touching them calls events within the program.
- *Interaction with multiple users in real time.*
  Networked telecommunications allow for the simultaneous support of multiple users within the *Fun House*. For the demonstration between CMU and Munich, the users selected the Dracula and Cookie Man personas from the library. Each user could see the other, had an independent point of view, and could move objects.
- *Links to moving objects.*
  The *Fun House* features a Merry-go-round; users can grab hold and catch a ride while music plays.
- *Objects attach themselves to users.*
  The *Fun House* features a Flying Saucer ride, where users are transported up into the space craft, and they can pilot its flight. The event calls the "beaming up" of the user and a whirring sound associated with flying saucers.
- *Attributes of physical laws.*
  The *Fun House* features a Ball Game, where users pick up a ball and throw it at targets. The ball falls, bounces, and loses velocity. Thus gravity, velocity, and friction are articulated. The motion of the ball is sound intensive.

New directions

Following the *Fun House,* a number of applications for Ford Motor Company, were designed, and discussed in detail below. However, while working on the applications, the project team became increasingly interested in approaching the immersion environment as a site where things can be constructed or created. For Ford, virtual reality was to be utilized as a virtual design studio, but what are other approaches?

Currently under design are three applications for a public institution or educational setting; they are also network capable: the *Music Room, Construction Room,* and *Painting Room*. These are friendly and intuitive environments

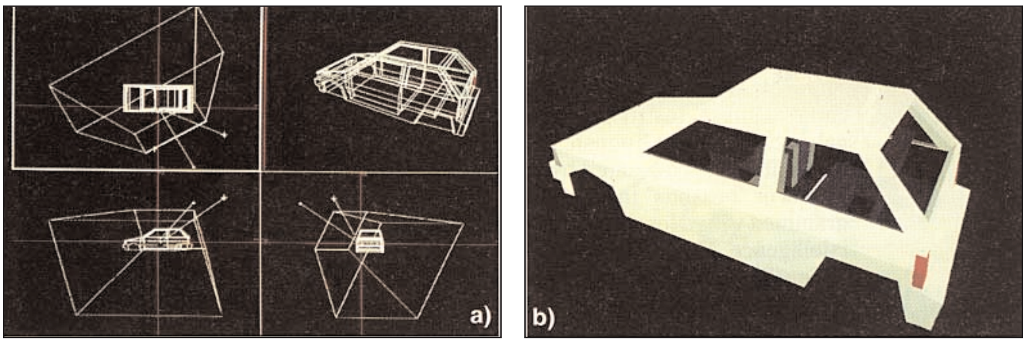


Figure 4 a) Outside, and b) wire frame model of Ford Festiva, from Virtual Test track, a network application. Produced for the Ford Motor Company, USA. Designed by Carl Eugene Loeffler

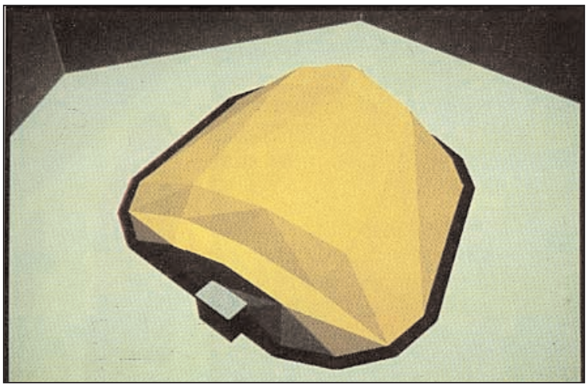


Figure 5 Overview of two mile long Virtual Test track, produced for the Ford Motor Company, USA. Designed by Carl Eugene Loeffler

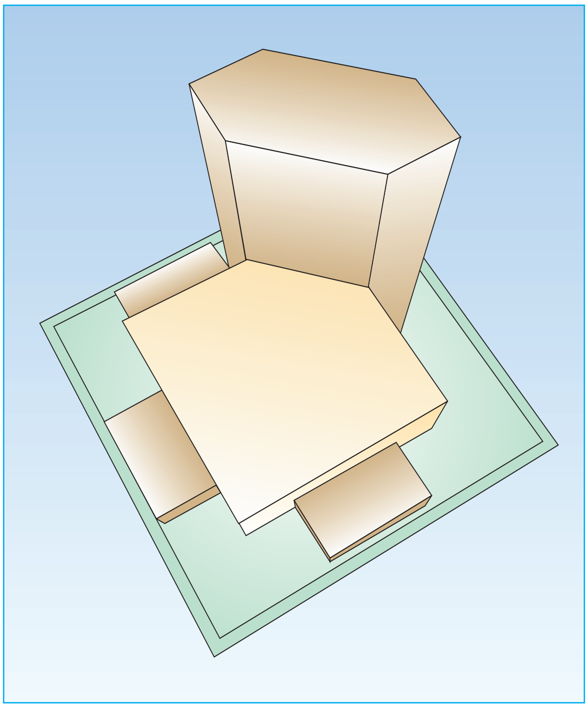


Figure 6 Overview of the Virtual Polis, a 3-D "city" inhabited by networked end users. Features high rise apartment building, private apartments, park, three stores. Produced for VR Vienna-93, Austria. Designed by Carl Eugene Loeffler

which require little learning curve to utilize. Instructions are bilingual, in Spanish and English, and the environment is co-habited by small agents or "beasons" that are programmed with a low level artificial intelligence. There are guides to the various interactive objects, and they demonstrate how the environment functions by literal illustration. In the *Music Room* they run around and make contact with the instruments, and thus play music. Users can see which instruments produce what sounds and how to perform them. Intuitive controls are available for navigating around in the room.

The *Music Room* contains three basic instruments. The largest is a large six note keyboard attached to a wall. This instrument plays a pentatonic scale in three voices – orchestra, choir, and percussion. It is performed by touching the keys, or by simply waving ones hand within close proximity. The other instruments are a drum and shakers.

The *Construction Room* is designed for young children. It contains building blocks which can be assembled to construct objects, sort of a virtual Lego set. In this case, there is a nearly infinite supply of blocks, and one can enter into some of the objects created, such as a house. The "beasons" co-inhabit this site as well, bounce merrily on the blocks, and illustrate how to stack them.

The *Painting Studio* is quite literal – a site for making paintings or graffiti. The user can select from a number of "brush" effects, and choose colors.

As of this writing, negotiations are underway to present these three applications are in design stages, and intended for a public science museum setting, networked with other facilities. They are also designed for use by school districts and other institutions.

The Virtual City

Another application currently under design is a virtual city. Inspired in part by the *Music Room* type applications, the city is an actual city, inhabited by a multitude of participants, and each with their own purposes. Imagine a virtual city complete with private spaces or domiciles, parks, stores, entertainment centers. As much as a grand social experiment, it also is a far reaching graphical user interface (GUI) for electronic home shopping and entertainment. Precedent for such an application as the city is *Habitat,* a commercial online service available from Fujitsu in Japan, which features two dimensional applications, and currently has 10,000 subscribers.

The concept of a city project was previously discussed, among the team. However, the conception of it accelerated, when approached by a film production company to produce a virtual set for a commercially distributed motion picture. The set would of course be a city, and from that point the virtual city began to quickly formulate.

The salient points of the virtual city include:

- a distributed, three dimensional inhabitable environment
- investigation of tele-existence in a distributed virtual construct
- capability of supporting potentially unlimited participants
- private spaces, property and moral code
- exploration of tools to alter the environment, while inhabiting it
- interface (GUI) for home shopping and entertainment.

The idea of a distributed application based on the notion of an inhabited city, is fascinating. Traversing the city and encountering other inhabitants will be a startling experience.

Teleconferencing and design

The last area of investigation includes distributed virtual reality as an interface for teleconferencing and design. The range of possible applications is broad, but education and industry are obvious examples.

Education can benefit with regard to long distance learning, and the industry can gain from a higher level of video teleconferencing. This raises the question, what is the advantage of distributed virtual reality over video teleconferencing. And the answer is, the relationship to the subject.

In a teleconferencing session employing distributed virtual reality, multiple participants can share a dynamic relationship with their subject. For example, imagine a team of automobile designers discussing options via video teleconferencing. To look at the subject, they might program a pre-recorded videotape, highlighting the desired aspects.

In contrast, for the Ford Motor Company a distributed *Virtual Showroom* and *Virtual Test Track* was designed. During this teleconference, the participants can actually traverse around the car. Open doors, hood and trunk. Test drive it. And in detailed applications, examine specific, even minute parts in detail.

While the Ford showroom and driving applications were produced from from a consumer standpoint, it has become increasingly apparent that they could bring benefit to teleconferencing sessions. Their key advantage, is the dynamic relationship with the subject. Of course the subject need not be automobiles, and applications can be developed to serve a wide range of interests.

Also produced was a proof of concept demonstration of a *Virtual Design Station,* re-inforcing the actuality to approach virtual reality as a site to build things. Design is used broadly here, inclusive of other multi-media.

The following are salient aspects of a design studio which would employ distributed virtual reality:

- The virtual environment supports interaction among networked remote production teams, for the purpose of industrial design and teleconferencing.
- The application establishes a relationship between an actual workstation, and a virtual workstation, operators have the capability of switching back and forth, employing a windowing method.
- Tele-existence is made evident thru synchronous voice communication, and the capability of each member to "see" the other members in the virtual environment.
- Stations consist of display, stylus, keyboard and mouse; additional input devices include head mounted displays, data gloves, and machine vision for voice and gesture recognition.
- Design teams utilize proprietary software.

The advantages of, distributed design stations are numerous, but an essential point is economy. The other key point is human experience. Teams located in remote sites and benefit from a collective design experience.

Connectivity

The basis for distributed virtual reality is a function of telecommunications. Two or more sites are joined by an operating system, which can employ a number of telecommunication delivery services

- direct dial up lines
- Internet computer network
- high band networks
- cable television
- wireless.

The project is at the forefront of the investigation of connected immersion environments. Presently a single point to point link, employing low band (9600 baud) modems is supported. The demonstration between CMU and Munich mentioned earlier, proved to be a great success, and the update delay between the two cities was imperceptible. Servers and broadband telecommunications are in planning, as discussed below.

Select functions for point to point include:

- providing all functions of the virtual world creation software in a distributed manner; the world and its attributes are distributed to each node, and one node is specified to be the controller
- providing constant views and updates of each users's object manipulations; users can move objects, including themselves, and updates to position and change occur with imperceptible update cycles
- writing and saving files to record the manipulations to objects; users can change worlds and carry an object with them into another world.

More connectivity

As of this writing, the team has begun the programming of a distributed client-server code. Here multiple users can share an immersion environment by interfacing with a node. The following are the points of in investigation.

- The formation of a client-server model, where multiple users can simultaneously share immersion environments
- The servers or nodes are to be located across the world and can be updated automatically via the Internet
- The nodes will offer sites for access and distribution of virtual reality software
- The nodes will support multiple platforms.

The next phase of the project will be in support of broadband communication. And to further facilitate this phase, a consortium has recently been developed with associates located in Japan, Scandinavia, and the United States. Over the following years the members will conduct technology transfers and testbed projects. Actual applications are scheduled for development. Members

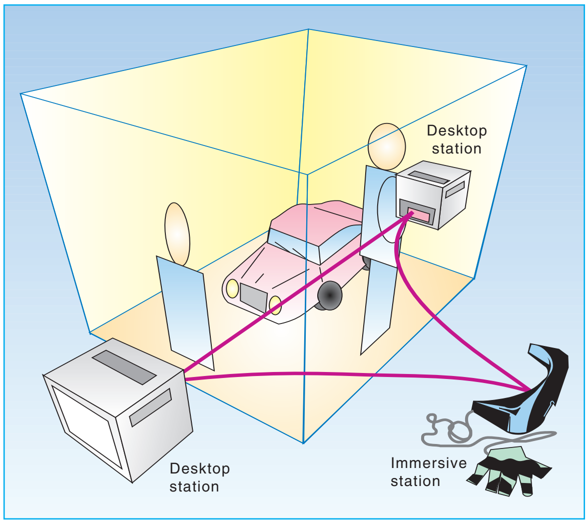
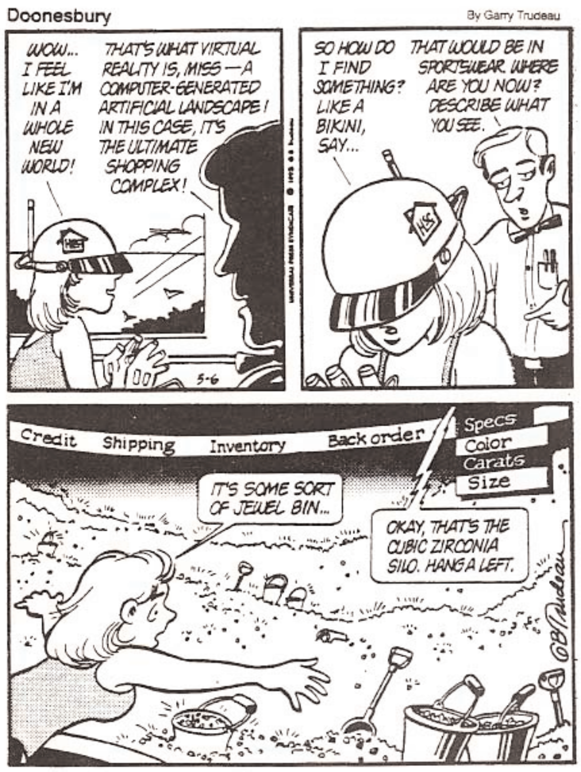


Figure 7



immersion environment, capable of supporting multiple users, with each having the possibility to change the existing virtual world or construct a new one. The promise of constructing virtual worlds while within an immersion environment is open ended. And it can be extended to any number of educational, entertainment and industrial purposes.

Distributed virtual reality has a history and has been given many different forms, shaped by varied intentions. It also has the promise of a future, marking the advancing edge of a new industry.

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Acknowledgements

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Coordination: challenge of the nineties

Multimedia as a coordination technology

BY PER M SCHIEFLOE AND TOR G SYVERTSEN

654.1:681.3

Towards a new economic order

The economy of the industrialised nations is changing, rapidly and dramatically. Obvious signs are problems in traditional industries, low growth rates, fiscal deficits and rising unemployment. Popular as well as political understanding often interprets this as a cyclic problem, expecting that the reappearance of prosperity and new jobs is just a question of time. An alternative and more firmly grounded hypotheses is that we are witnessing signs of a *dramatic shift in the fundamental structure of the economy of the modern world*.

Ever since the transformation from agrarian to industrialised societies, growth and competitiveness have been based on increased consumption of natural resources, energy and labour, accompanied by a continuous flow of innovations and improved production technology. This is no longer so. Even if the innovation rate is higher than ever, the situation is characterised by reduced demand for traditional products, falling prices for many natural resources, global overcapacity and decreasing number of employees in the sectors of industry which laid the foundation for prosperity throughout most of the century. In the evolving global marketplace both specialising and competition is increasing.

What is evolving today is what we, somewhat incorrectly, may call a post-industrial society. The term is incorrect, insofar as industrial production still will be the backbone of most national economies. It is at the same time correct, taking into consideration two important facts. The first is that the industrial employment and the percentage of GNP based on material products are decreasing. The second is that the basic strategic commodity no longer is natural resources or low-skilled labour, but *knowledge* (Schwartz).

Evidence of this transition is easily observable. Industrial production is changing, from being labour-intensive to being knowledge-intensive. An illustrative example is that in a car, 40 % of the cost is determined by materials and 25 % by labour. In a silicon chip, less than 1 % of the cost depends on materials and no more than 10 % on labour, in the sense handling of material products. The rest is knowledge, materialised as the processing of information and labelled research, development, design, production planning, organising, marketing and communication.

The organisational challenge

Like it or not, the years ahead will be an era of change and competition.

When markets shift, technologies proliferate, competitors multiply, and products become obsolete almost overnight, *successful companies are those that constantly create new knowledge, disseminate it throughout the organisation and quickly embody it, either in new products, modifications in existing products or improvements in production processes*.

Performance and competitiveness depend on creativity and efficiency. Two elements seem to be decisive to obtain this.

The first is the ability to make *innovative use of information technology*. The second is an *understanding of the tasks to be performed* and the organisation which is to perform them. Combined, this makes possible the development and implementation of a technology that supports the "three C's": *Communication, Cooperation, and Coordination*.

Organisations can be approached from different theoretical and analytical viewpoints. In order to grasp both complexity and interdependencies, it may be useful to picture a specific organisation as an open system, consisting of a few basic elements. At the same time it is important to keep in mind that this system is also an arena for action and for the pursuit of individual as well as collective goals.

Actors operating on this arena behave within the constraints of a set of intellectual frames, which may be phrased as cognitive structures.

Rebuilding and expanding Leavitt we can illustrate the main analytical elements of the organisation as in Figure 1.

A narrow definition of *actors* includes only those who are working in the organisation. A somewhat broader definition also includes others who have direct interests in the organisation and are in a position where they can exert direct influence, e.g. owners, local authorities and union officials.

Actors invest time, money, effort or prestige in the organisation in order to obtain some kinds of rewards. Rewards may be of different kinds; economical, psychological, political or ideological. The outcome of efforts may be observed as money or other material goods, power, reputation or as the fulfilment of more subtle psychological needs.

The interests of the different actors may be coherent as well as conflicting, actors may cooperate, compete or engage in internal struggles. They can operate as individuals, but are also prone to form alliances. Some organisations are harmonious and peaceful, whereas others only can be understood when considered as political arenas.

The *technology* is the purposeful application of machinery and equipment used for handling material products and information in order to produce the necessary goods and services, both for delivery to the external market and for internal consumption.

Parts of the *structure* may be mapped in an organisational chart, which depicts formal hierarchy and division of labour. Other parts consist of formal role defini-

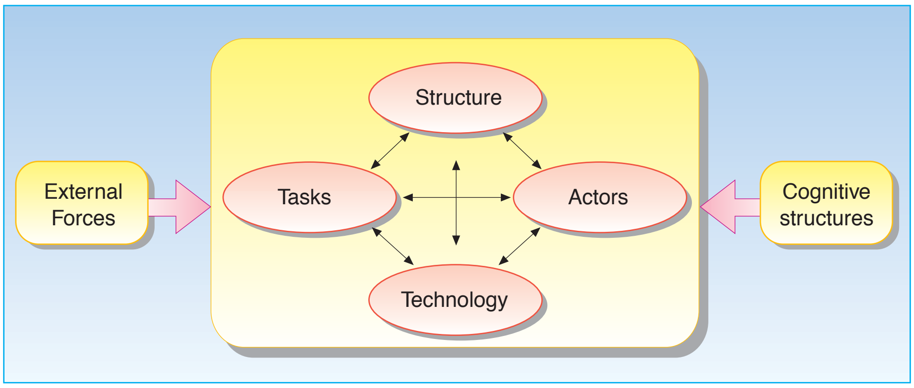

Figure 1 Elements of organisation

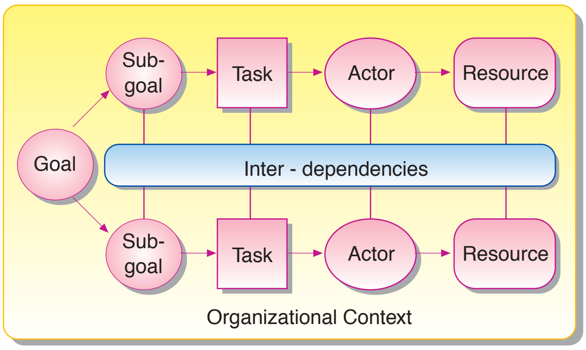

Figure 2 Coordination model

tions, rules and working procedures. Organisational structures may be more or less bureaucratic.

It is a well-known fact that the formal structure of an organisation is as a rule accompanied by informal structures, being manifested as informal groups and social networks. Diverse kinds of such informal arrangements may split or unite parts of the organisation and they may criss-cross and penetrate formal boundaries.

Informal structures play an important role in, among others, communication, decision-making, development and maintenance of culture, socialisation, rule enforcement and social control. In a system-oriented approach to organisations, the informal structure is often said to be part of the organisation's social system.

The *tasks* are the jobs to be done in order to produce goods or services for external markets or for internal consumption. Tasks may be decomposed into sub-tasks.

External forces represent direct and indirect influences on the organisation, exerted by customers, suppliers, competitors, public authorities, unions, to name the most important. In the analysis of organisation this perspective is taken into account by treating organisations as *open systems*.

Cognitive structures are a common denominator for ways of thinking, for the accepted knowledge and beliefs, values, norms, language, myths and other elements usually summed up under the heading organisational culture.

The scientific understanding of organisation is necessarily built upon all these basic elements, the importance of which, however, may vary.

Effectiveness by coordination

There is widespread agreement among professional observers of business that successful performance in the fundamental arenas of the nineties requires flexibility and organic approaches, and that there is little room for rigid bureaucracy.

The effective organisations make optimal use of its human and material resources in a time- and cost-effective manner, where people *work together* to achieve goals. Success, and survival, also depends on the organisation's ability to develop itself, partly through innovation, partly through learning, by taking care of knowledge created and experiences made.

Working together, combining knowledge and transfer of experiences requires *coordination*. Following (Malone & Crowston 1992) we can define this broadly as *"the act of working together"*.

If we look more closely into the concept, we can identify the components of coordination; *goals, actors,* and *activities*.

The goals are something to be achieved. In economical and technical reasoning organisational goals are usually taken for granted. Empirical studies have demonstrated that this assumption more often than not is a dubious one. Formulation and selection of goals is regularly a question of internal struggles, contesting interests and different perceptions of reality.

The activities are the actions necessary to perform the different sub-tasks of the goal. The actors are the participants, within as well as outside of the organisation, whose efforts have to be combined.

Actors and activities are linked by *interdependencies*. A more narrow definition based on this decomposition may be:

Coordination is the act of managing interdependencies between activities. (ibid.)

Compared to the traditional view, focus has been shifted from the components to the *relationships* between them, see Figure 2. This represents a more fundamental change than may be apparent at a first glance; the dynamics of a system are determined by the relationships between the components of the system, not by the components themselves.

Coordination within an organisational system can, broadly speaking, be obtained in three different ways.

Coordination by *market* is the most decentralised form, based on the assumption that coordination will be an automatic outcome, produced by the pursuit of individual actors' self-interest. Borrowing a term from microeconomics we may speak of coordination by the invisible guiding hand.

The establishment of *internal markets* represents a new development in intra-organisational coordination. By introducing consumer sovereignty and a price system, the aim is better mutual adjustments and thereby more cost-effective use of the organisation's resources.

The traditional form for coordination is through *hierarchy,* i.e. by means of bureaucracy and overt control mechanisms. Such bureaucratic operation involves the breaking down of complex tasks in a number of sub-tasks, which are distributed to different actors by a set of rules, governing responsibilities and content of work.

Dealing with complicated tasks under complex or changing conditions demands flexibility. Necessary coordination in such cases are mostly obtained through informal mechanisms. The decisive elements are personal relations, based upon trust and knowledge and expressed through open or hidden *social networks*. Such informal social systems often play an important and sometimes crucial role in the coordination of complex organisational activities.

For all these mechanisms coordination technologies may be a relevant topic.

The new information technologies

The basic principles of coordination are not new, but their relative importance are changing according to the shifts in economy, markets, technology and culture.

A major transition in the information and communication technologies is appearing just now, which will have a profound effect on coordination and thereby organisation of work. The following sections will address the characteristics of the novel technology, some implications for the organisations, and the location of multimedia as a part of the whole picture.

Back in the late seventies, the Japanese electronics corporation NEC developed a strategy for what they call *C&C technology,* where C&C denotes *Computers and Communications*. At that time only a few visionaries could point out the direction so clearly as NEC did, but today the trends of development have become evident to most of us, and we see a merging of computing, telecommunications, publishing, and broadcasting into a new, global digital medium for information and communication. A comprehensive presentation of the technology and some of it's implications is found in Scientific American, September 1991.

Computing has, during the past three decades, evolved from specialised calculating devices used by a few experts, into general information tools used by everyone. Computers and software enhance our individual capabilities in performing daily work like writing, drawing, calculating, filing, and so on. Word processors, spreadsheets, computer aided design tools, databases, etc. have been made easily available by personal computers and graphical user interfaces. This technology has already entailed profound changes in the organisation of work; tasks that previously were handled by assistants like draftsmen, clerks or typewriters are now performed by the professionals themselves (e.g. engineers) as an integrated part of the information process.

Until now, the computer has been used either to *automate* routine work, or to enhance the capabilities of *individual knowledge workers* like writers, engineers, scientists. The new paradigm of computing, based on networking, will enable an *organisation to augment its capabilities and performance* in a similar way. Some of the basic characteristics of the new paradigm are as follows:

- The *networked computer* will enlarge the abilities and performance of groups and organisations in a similar manner that the personal computer has enabled the individuals.
- The digital networks provide possibilities for *acquiring information and solving problems in new ways,* by broadcasting requests, and gaining access to previously unknown or inaccessible knowledge sources.
- Distributed multimedia enable the integration of *informal information* like speech, pictures and video with traditional information types like text, numbers and structured data, thereby expanding the communication bandwidth.
- Object-oriented information framework provide a *new medium for definition and sharing of knowledge* about products and processes, where information and knowledge may be developed, cultivated and reused.
- Computers are becoming *mobile,* making information and communication available everywhere, independent of space and time.
- Small and inexpensive digital transponders can be attached as information carriers to any object we want current information about, providing a means for a truly distributed information base.

The prevailing paradigm of computing has for some years been based on large, centralised computers for corporate tasks like accounting, and small, disconnected computers for individual tasks like word processing or drafting. The next paradigm is based on many computers, people and other resources effectively connected in a network enabling groups of persons to augment their cooperative efforts.

Electronic mail and various conferencing systems are in common use within the research community and at alert corporations. New functionality is constantly added, like decision support, and multimedia communication to support the sharing and cultivation of tacit knowledge.

Many people consider information technology as a novelty, invented after the second World War. In fact, digital computers is basically a *new generation* of information technology. The powers and capabilities of this technology exceeds the previous ones by orders of magnitude, but the basic purposes remain the same: *information and communication.* In fact, any information is produced for the purpose of communication, in time (storage) or space (between humans, or computers).

The oldest known information technology has been found in the remnants of the ancient town of *Uruk* between the rivers of Eufrates and Tigris in Mesopotamia (today's Iraq). Uruk was one of the first permanent settlements we have any knowledge about, and the archaeologists have uncovered some small clayboards with engraved signs and symbols. The clayboards dates back to the Sumerians (about 3000 BC), and this primitive information technology was probably a significant factor when human development suddenly took a new direction.

The apparently trifling clayboards revealed the invention of cuneiform writing, a technique for *symbolic representation of abstract ideas,* like numbers. This represents a major leap in human development.

Far older depictions exist, like cave paintings dating back 30 000 years, or the stone carvings like the ones that are used to symbolise the Lillehammer Winter Olympics, but these are mainly pictures of concrete, physical objects like animals and hunters.

This primitive information technology enabled the exchange of ideas between individuals without being in the same place at the same time. People in distant places and future generations could learn from the progress and failures of others, and share their insight and skills. Those who were able to reason could collect facts from everyday life, and extract those parts that were prominent and could contribute wisdom. This simple technology must have been of profound importance for the advancements of the civilisations in Mesopotamia, by the Nile, in India and China, and in Central America.

The next invention in information technology was perhaps papyrus, and this technology was used in more refined forms for centuries, until Johann Gutenberg developed his famous printing technique based on moulded character types of metal. Before, books had been printed from woodcuts of complete pages, or neatly copied by hand. The new technique enabled large-scale production, and hence cheaper distribution of books.

In the beginning, the new printing method was used to reproduce older, religious writings. Not only the content, but also the style was imitated. Gutenberg's famous 42-lined bible from 1455 is probably the best example of *incunabulas,* as these early printed books are called. The monastery typography with intricate characters was, however, not very well suited for the new printing technique. The more interesting applications of Gutenberg's technique did not occur until people liberated the printing from the constraints posed by the religious substance, the hand-written style, and the Latin language.

The Gutenberg art of printing was a crucial factor for the revolutions during the Renaissance and the Enlightenment; within religion, philosophy, science, and technology. The dissemination and discussion of new ideas, the advancements of science and technology, and the accumulation of knowledge and experiences, were deeply dependent on the printed book.

Diderot and D'Alemberts *Encyclopaedia,* compiled in 28 volumes in the period 1751-72 is the most eminent example of the impact that the printed book had on the available knowledge in the western world. What followed was a fundamental change of man's conception of himself and the world – the individual man with a free will was born – and soon came the industrial revolution. One can speculate why the industrial revolution did not arise in China which in many respects possessed favourable conditions compared to Europe – our guess is that the Gutenberg printing technique could only be efficient with the *alphabet,* with a small number of basic characters that can be combined into any number of meaningful words and sentences. The Chinese character set would be too numerous for efficient moulding and typesetting, just because each character conveys a lot of information.

Communication media

The vehicle for any coordination is communication, and the characteristics and quality of communication is determined by the medium, hence the technological structure of information is mainly a matter of media. Digital media facilitates the management of information stored in digital form, where the basic elements are the bit and the pointer. (It is remarkable that any kind of information structure can be built from these two simplest elements one can imagine).

Digital media can be classified in three categories according to the primary purpose or properties:

- *Storage;* the common technologies for digital storage media are magnetic and optical. The information is stored according to some physical or logical structures that facilitate retrieval, but the information can not be displayed until transferred from the storage medium to a presentation medium.

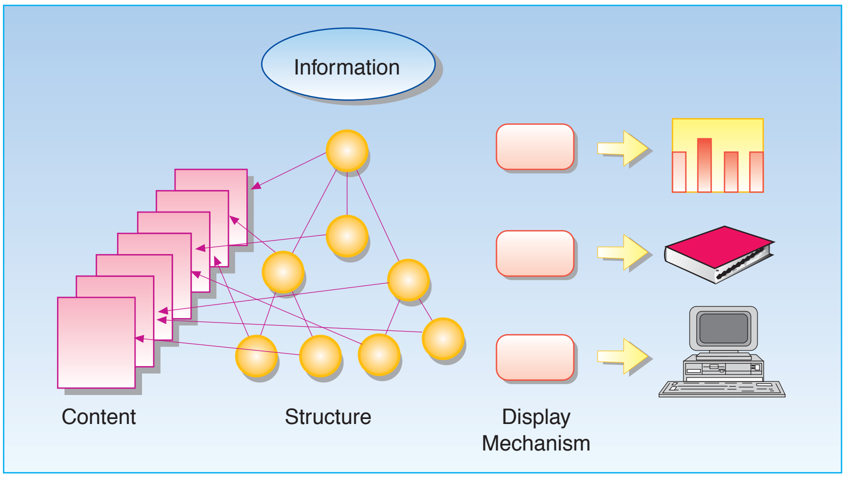

Figure 3 Digital information

- *Presentation;* the presentation medium may also be denoted a *display*. The common use of this term is for text and pictures on a monitor, but in the general sense it could also be sound, tactile media (e g generating Braille patterns for the blind), paper or microfilm.
- *Distribution;* or transfer of information to the recipients. Media for distribution might be the same as for storage (e.g. diskettes), but also electronic, optical or radio based networks fall in this category.

In a historical perspective, the three categories of media have been inseparable, and perhaps more important, the information has traditionally been an integral part of the medium. With the emergence of the computer as a medium, it is for the first time possible to separate the information itself from the presentation of it. Access and display is performed by different mechanisms, and the same information can be used in many different ways. This principle is illustrated in Figure 3. A simple example is a text that can be displayed as characters on a screen (or paper), but the same text can also be (dis-)played as speech by a synthetic voice generator.

The tremendous potential of this separation have not yet been realised, because digital information systems to a large extent have been imitations of the manual information processes based on paper as information medium (similar to the medieval incunabulas). In the first software systems for newspaper typesetting, the lines appeared from the bottom end of the monitor, probably because this resembled the sequence of typesetting with letter cases. Another example is software systems for library services, which usually have imitated catalogue cards on the screen.

In the new framework of digital information as depicted in Figure 3, paper is regarded as a presentation medium, being static and separated from the stored information structures.

A medium is used to communicate information between different systems (people or computers) holding different models, and the new medium is characterised by the flexibility, dynamics and responsivity towards the user of the medium. The medium is a *carrier of symbols* between the sender and receiver in a communication process, where effective communication requires a common understanding of the syntax and semantics of the notion. Symbols are always interpreted within a cultural framework, and body language demonstrates how sharp communication can be at the informal level, whereas the very formal communication via a database may be very fuzzy because the context is not shared between the sender and the receiver.

In a historical perspective the symbolism has been developed to match the medium:

- *Clayboards:* cuneiform writing was the natural symbolism for imprinting of pins in wet clay.
- *Papyrus:* painted characters like the Arabic or Japanese are natural for using a wet brush and ink on papyrus.
- *The printing press:* the technique with individual, moulded characters

required a simple typography to be efficient. The Venetian printer Aldus Manutius invented this typography after years of struggle with imitations of the hand-written, monastery styles.

- *Computers:* The Apple Macintosh represented the breakthrough for the first type of symbolism that were particularly developed to match the characteristics of the computer as a medium. The *icons* are dynamic symbols that provide a *response* when they are touched, by exploding into a document, a visual feedback or a movement.

When looking at the recent developments in computer graphics and virtual reality technologies, exciting opportunities for the creation of new languages based on powerful, dynamic symbolism will be available in the near future.

In the context of coordination, we suggest to regard the networked, multimedia computer as *a* medium for communication, not as multiple media (multimedia).

The new medium is distinguished by the properties of being *responsive, dynamic,* and *flexible,* and it may be used to simulate or replace other kinds of communication (like telephone or television), but it can also be used in innovative ways that utilises the characteristics of the medium.

The success of the Apple Macintosh computer has been attributed to the graphical user interface which facilitates direct manipulation of objects on the screen. While this kind of interface was instrumental for implementation, the more important part was the desktop metaphor, that is the underlying conceptual model of a virtual desktop.

As the personal computer has provided a virtual desktop, the computer networks will enable a similar concept of the *virtual organisation* where the computer screen and other access devices provide windows into a virtual space of information, actors, and activities.

Until now, this incredible new medium has mainly been used to imitate paper based documents like passive drawings, specifications and descriptions. These are two-dimensional projections matching the capabilities of paper as a medium, and on a communication principle where the sender determines the information needs of the receiver. Both these principles are absurd when considering the immense capabilities of the new medium for representation and conveyance of information and knowledge.

Drexler is speaking about the new medium as *"magic paper"* (Drexler 1990), which is in essence the *Memex,* proposed by Vannevar Bush in his famous article *As We May Think* that appeared in the journal *Atlantic Monthly* in August 1945. In retrospect, this apparently modest article should be regarded as a cornerstone in the building of modern information technology. Memex is an abbreviation for *"Memory Expander"*, a vision of the computer as a mechanism (or medium) for augmentation of the capabilities of the human mind. A few years later, this article triggered the marvellous works of Douglas Engelbart. Ted Nelson coined the word *hypertext* in the early sixties, grown from the seeds of Vannevar Bush.

Hypertext is a non-linear text (or information) structure, where information elements are linked in a multi-dimensional network. Hypertext is an information structure, while multimedia is a blended presentation (or display) format for this information. Hypermedia is the combination of hypertext structures and multimedia displays. The main purpose of hypertext is to build semantic information structures, while multimedia mainly apply to the presentation mechanisms, refer to Figure 3. The importance of structure as a major semantic mechanism is emphasised by a definition of meaning:

> *"The secret of what anything means to us depends on how we've connected it to all the other things we know. That's why it's almost always wrong to seek the "real meaning" of anything. A thing with just one meaning has scarcely any meaning at all."* (Minsky 1986)

Coordination processes

The act of coordination may be described in terms of successively deeper levels of processes, each of which depends on the level below it. Table 1 is taken from (Malone and Crowston 1990), who have identified four process levels with different characteristics, and increasing complexity from bottom up.

According to this scheme, we see that the structuring of information becomes crucial to the bottom layer, and to the language definition part of the layer above. Multimedia communication, like desktop videoconferencing, may in particular apply to the group decision making layer, where the potential may be substantial for geographically dispersed groups, and large teams working together over long periods of time in continuos decision-making processes like engineering design of complex technical systems. In such situations it is also required to operate on a shared, digital model of the physical system, with common, global views (or windows) for communication, negotiation, etc.

The communication layer may be expanded to the three-layer scheme found in Table 2.

To get an understanding of the differences between the various levels of communication, consider the numbers 1.82, 22144819511, and the character string 'John Smith'. These are three data items, and they provide no information at all (one may try a qualified guess that 'John

Table 1 Processes underlying coordination (from Malone and Crowston (1990))

Process level	*Components*	*Examples of generic processes*
Coordination	goals, activities, actors, resources, interdependencies	identifying goals, ordering activities, assigning activities to actors, allocating resources, synchronising activities
Group decision-making	goals, actors, alternatives, evaluations, choices	proposing alternatives, evaluating alternatives, making choices (e.g. by authority, consensus, or voting)
Communication	senders, receivers, messages, languages	establishing common languages, selecting receivers (routing), transporting message (delivering)
Perception of common objects	actors, objects	seeing same physical objects, accessing shared databases

Table 2 Levels of communication

Communication level	Purpose	Contents
Logic	Sharing of knowledge	Data structures are combined with methods into objects with state as well as behaviour, and with a reference to the definition of the object type
Semantic	Exchange of information	Individual data items are combined into data structures by relations that adds information contents
Syntactic	Transfer of data	Encoding of symbols, into basic data items like numbers, character strings, sound snippets, etc.

Smith' is the name of a man, but replace it with 'Llongsangelhagb Ashnam' and it is easy to realise that the information is not a part of the data item, but reside in our cultural minds). If we add a *relationship* by saying that 1.82 is a length measured in meters, some information is provided, but still very little, just a reference to the SI system of units. 1.82 meters may be the height of a person named 'John Smith', or perhaps his personal record in high-jumping. The number 22144819511 may be a social security number, a telephone number, a bank account, or whatever. There is nothing in the data items that can tell the information, because the information content is determined by the relationships between the data items, and by references to the external world (like the system of units).

The relationships between data items are usually not provided with the data, so we need some kind of interpreter in order to understand them. Most interpreters are social and a part of our culture, and we are not used to think about them as such. A telephone dictionary is for example an interpreter that relates the names, addresses, and telephone numbers. Exchange of information between a sender and a receiver is usually based upon the assumption that both parties have compatible interpreters, otherwise misunderstandings may occur. This kind of information exchange is typical between different computer programs, where the definition of the data structures reside in the programs, and are not part of the data that are transferred between them. In this case only predefined information structures can be exchanged, and any new structures require modifications to be made to both programs before data transfer can take place.

At the upper level of communication, intended for sharing of knowledge, the definition of the information objects, the various relationships between them, and references to the context should be added. These kinds of mechanisms could allow the information to be explored, and understood even if the structures are not predefined. It is, however, necessary to build any new structures in terms of existing ones, by combination, specialisation or abstraction.

The area of knowledge representation has been explored for decades by researchers in so-called 'Artificial Intelligence', and a number of approaches and techniques are available. The paradigm of object-oriented modelling seems to become the merger of several programming techniques, and multimedia information types like speech and video provide possibilities to add informal communication which may speed up the process of human interpretation and understanding of the meaning embedded in the information.

Coordination and group decision-making in complex processes like engineering design require a common understanding of information structures with multiple views, for instance various engineering disciplines (process, instrumentation,

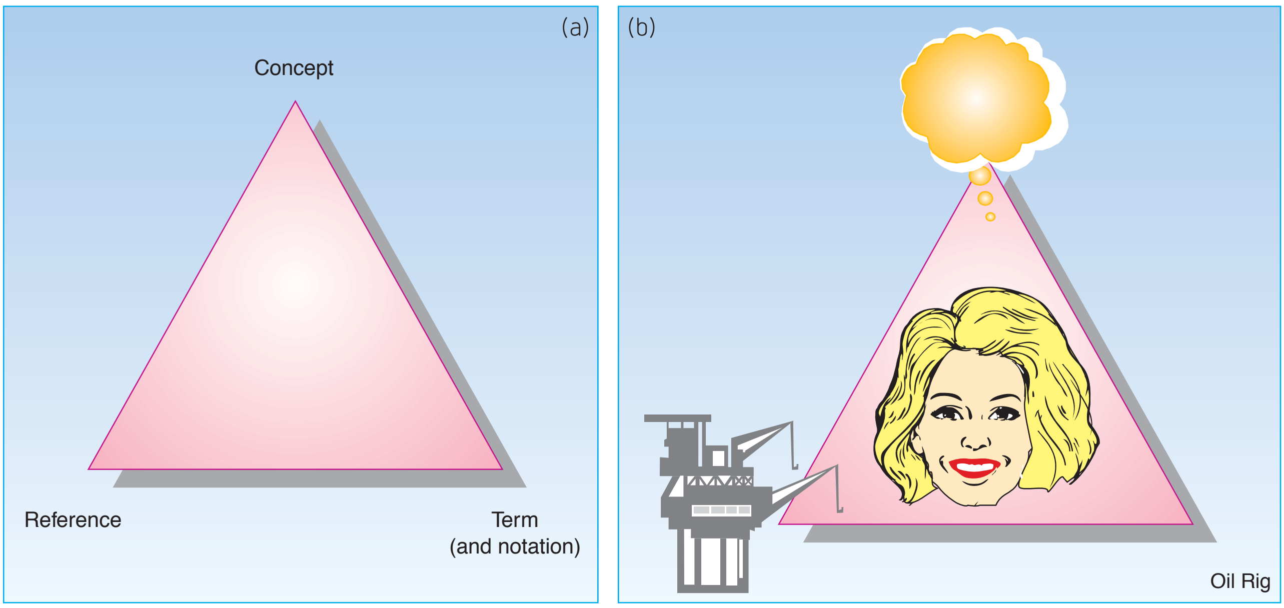

Figure 4 (a) Ogden's Triangle, (b) Example electrical, etc.), or different levels of aggregation (e.g. levels in an organisation).

Breakdown of a communication process may be caused by several reasons, like terminology, concepts, references, context and noise. The basic elements of understanding may be illustrated in a simplified, schematic view by Ogden's triangle as shown in Figure 4.

The *concept* is the abstract idea created in one's mind (or maybe in a computer system). Concepts are usually abstract categories that are represented by certain patterns in the brain (or electronic states in a computer), and are most likely to be a combination of function and structure (Minsky). For example a stool and a table may have the same structure, but the functions are different, and thereby the concepts are related, but different.

A concept is communicated by a *term,* like 'stool' or 'table'. There may be several terms denoting variants of the same concept, like 'office chair' or 'rocking chair'. A term may comprise combination of words, or completely different sets of symbols like traffic signs, icons, or ritual expressions. The appearance of a term is based on a medium to carry the term, and a notation which is the encoding. A word may be spoken or typed, representing the same term in sound waves and printed characters, respectively.

The third vertex of Ogden's triangle is the *reference,* which provides the cultural and contextual frame for interpretation of the term and thereby understand the meaning by creating the intended concept.

Misunderstanding occurs frequently because the same term is used for different concepts (e g the term 'structure' has different meanings in structural engineering and in computer science), or when the frame of reference is different.

Figure 5 illustrates how the term 'oil rig' may be interpreted differently in the North Sea and in Oklahoma.

Communication and coordination problems frequently occur because the sender and receiver side have incompatible Ogden's triangles. The terms may be well understood in a technical manner, but the concepts and the references may be quite different.

Multimedia communication may relieve some of the problems in communication over distance or time, because the high bandwidth allows conceptual and referential frames to be captured and transmitted as supplementary information elements that the receiver can explore. In a synchronous communication mode, the receiver can simply ask for explanations of terms that are not comprehended.

Coordination

Whereas coordination represents a major organisational challenge, new technologies for communication and information handling represents a hitherto mostly untapped potential for approaching this. Their orders of magnitude are probably more powerful than any previous organisational technology. Their impact on organisations may correspond to this. Introduction of new coordination-effective technologies will lead to new coordination-intensive structures, giving little room for traditional ways of working and administering. Changes may be painful, for many organisations so painful that they have small possibilities for survival. In such profound processes of change, the introduction of technology alone will not be sufficient. What is needed is an adaptation of technology to organisation, and vice versa, as Michael Schrage has pointed out:

> *"... the networks to organisational hell are wired with good intentions. In the real world, even the best designed networks can have astonishingly perverse impacts. State-of-the-art systems frequently end up producing the exact opposite of the desired results. A network intended to flatten the corporate hierarchy mutates into a medium that reinforces autocracy. In fact, the politics of corporate networks turn out to be as vicious, venal and misleading as*

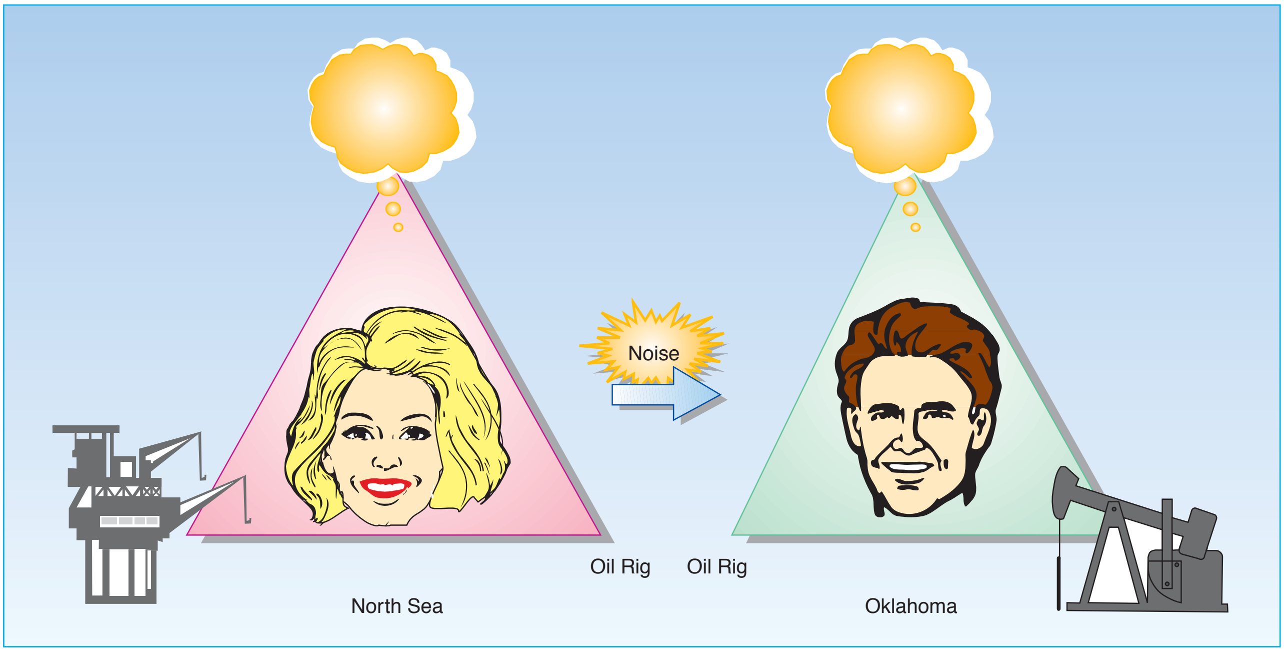

Figure 5 Different frames of reference

Program on Applied Coordination Technology (PAKT)

PAKT is a five-year cross-disciplinary research program established in 1993. Founders of the program are Statoil, Norwegian Telecom Research, and the University of Trondheim. The present budget is approximately NOK 5 mill per year.

PAKT is intended to be an *arena* for creative cooperation between professionals from industry and academia, working out strategic solutions to coordination problems for industry and trade. The core activity is a *doctorate program* within a range of problems in applied coordination technology. The program will employ about 15 doctoral and graduate students.

Coordination is a holistic approach to the management of *interdependencies* between activities, actors, resources and responsibilities in complex organisations striving to achieve a common set of goals.

The research focus in *PAKT* is the oil/gas industry, regarding the development and production of a license (i.e. an oil/gas field) as a coordination process.

Coordination technology is the knowledge about methods, techniques and tools for coordination. Networked, multimedia computers are considered as a new *medium for coordination,* enabling improved communication across large teams of people, and new ways of organising work.

In *PAKT,* coordination technology comprises three basic components:

- Innovative use of *information technology*
- Problems related to *engineering* and other disciplines
- Understanding of organisations through *social science*.

The research focuses on engineering, characterised by large projects involving many disciplines, with strong interdependencies between activities and actors, and relying on complex information and communication structures.

An important aspect of *PAKT* is to develop a novel concept for *cross-disciplinary collaboration* within the university. This assignment is itself a coordination problem, which is not easily resolved within the traditional, academic ways of work.

We emphasise participation in the international community of research and development, and want to establish relationships with other universities and research institutes working in various aspects of coordination technology.

PAKT project requirements

The research projects in *PAKT* are still in the definition phase, and the first bundle of projects will be defined during the fall of 1993. To be accepted, a project has to meet a set of five requirements in order to support the basic ideas of *PAKT:*

- The project must address a *'real world problem'*, that is a problem representing challenges or opportunities as conceived by our industrial partners.
- The project must address a problem that is complex and *coordination intensive,* which means many interdependencies between tasks, actors and resources.
- The project must contain components of *information or communication technologies,* or represent potential application areas for such technologies.
- The project should represent *organisational challenges* requiring an approach that includes organisational theory for problem analysis and solution.
- The project should have a *research potential*. Based on empirical and/or theoretical analysis, the projects should together provide knowledge that may be generalised and applied to other problem domains.

Five project areas have been identified, and are now in the definition phase:

- Network organisations
- Enterprise modelling
- Experience transfer and organisational learning
- Internal markets as a coordination mechanism
- New ways of working in coordination intensive structures.

Network organisations

A network organisation is an organisation where the various parts have more and looser connections than in the ordinary, hierarchical organisational structure. Several cooperating companies may also form a network organisation, e.g. one manufacturer and several suppliers.

One of the major advantages of the network organisation is the flexibility in adapt to turbulent market situations. The flexibility of an organisation is determined by the relationships between the individual parts, and the distance to the decision making authority.

The research on network organisations is intended to develop a scientific understanding of this knowledge domain, but at the same time apply the research to practical targets in real-world organisations.

The research object to be addressed is an oil production platform and its supporting functions. By focusing on the production platform, one may discover the needs for communication with other units, and what competence and other supplies they need. Emphasis is on the platform's cooperation with the surrounding supporting organisation, and various approaches will be taken (descriptive, analytic, normative and prescriptive).

The project will address technological as well as organisational aspects of coordination in network organisations.

Enterprise modelling

Enterprise modelling denotes the modelling of work processes, products, and organisations. The organisation possesses resources and control mechanisms, and forms the environment for execution of the work processes, and development and production of the products or services.

This project is carried out in close cooperation with the *Caesar Offshore* program, where all the major companies in the Norwegian oil/gas industry are partners. Caesar Offshore addresses the use of digital information and communication, with emphasise on improved work processes and a life-cycle perspective on the information management.

Modelling is one of the fundamental engineering techniques for describing, analysing, and understanding the behaviour of complex, dynamic systems. In *PAKT* focus is on *digital* modelling, that is models that can be represented, manipulated and analysed by use of computers.

The Enterprise Modelling project addresses both basic concepts and methodology for enterprise modelling, and applications within the Norwegian offshore industry. The purpose of the application part is to develop better understanding of the work processes in engineering, construction and operations of offshore installations. Characteristics of this kind of enterprises are large and complex products, dynamic organisations, and increasing concurrency of the work processes, posing heavy requirements for efficient coordination.

Transfer of experiences and organisational learning

The scope of this project area is transfer of experiences and knowledge, learning and culture, as means of coordination in complex organisations. This includes the capture, qualification, representation and dissemination of experiences related to technical systems and tasks. Some of the basic issues are:

- What is the set of valid knowledge in the organisation, and how is it captured, qualified, stored and transferred between individuals, tasks and functional areas?
- What are available technologies for support and improvement of processes involving knowledge and experience transfer?
- Organisational culture as a support or obstacle for organisational learning
- Information technology as a vehicle for organisational knowledge; potential, development, and practical use

New ways of working in coordination intensive structures

An increasing number of the tasks in a complex organisation appear as information- and coordination intensive. The organisation's capabilities to address these challenges, and develop organisational and technological solutions have substantial importance for quality and efficiency, and hence for competitiveness.

Coordination as a challenge may occur as a consequence of various situations like:

- complex, information demanding tasks
- involvement of various professional and functional groups
- geographical distance
- organisational complexity.

The development of an offshore oil/gas license is an example of an enterprise where all elements appear simultaneously.

Information technologies that may support coordination intensive activity include groupware, decision support systems, multimedia communication and distributed object management.

Experience has shown that the information systems will bring benefits only if the organisational context has been adopted to the technology, and if the involved participants have the necessary competence and the understanding of the entirety of the enterprise. This requires the proper combination of purposeful infra- and cognitive structures, common task understanding, communication skills and determination, consensus regarding the goals, and loyalty to the system.

Only the close coupling between people, tasks, organisation and technology can provide the synergy that present and future enterprises will demand.

This project is planned to use experimental installations of coordination technologies for implementing novel ways of working, and to study existing enterprises for the purpose of business process redesign.

Internal markets as a coordination mechanism

The theory of coordination through markets is built upon the conception that the individual actor's rational, value maximising endeavours sum up to rationality in terms of effective resource usage also at the aggregate level.

The establishment of an internal market inside an enterprise implies the subdivision of the organisation in individual business units that are expected to relate to each other as customers and suppliers.

The study of internal markets will focus on the effects, opportunities and limitations, and in particular address the following elements:

- *Structural prerequisites* according to management domains, distribution of responsibility, hierarchy, competence requirements, rules and regulations
- Changes in *organisational culture,* in terms of knowledge, values and attitudes
- *Different interests,* as found in various parts of the organisation, within the departments, at different levels, groups of professionals, geographical regions, etc.
- Formal and informal *reward systems*
- Communication *technologies*.

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anything you could hope to find in a presidential campaign.

Unfortunately, most companies prefer to ignore the fact that these networks don't just carry information; they also embody – for better or worse – the values of the organisation. Companies that don't understand – or kid themselves about – their core values are doomed to make painful, wasteful technology investments". (Schrage 1992.)

A major challenge is to combine the introduction and application of these technologies with an insightful redesign of the organisations around their core values and their critical information.

Efficient communication and coordination is not a matter of technology or geography, but of values, attitude and behaviour. Poor communication capabilities can never be overcome by adding more technology.

The skilful use of multimedia communication is not a straightforward undertaking, but requires a combination of competences not unlike what is found in a film team. Very few individuals or organisations possess these competences today, and new educational schemes need to be developed in order to meet the needs of the rather near future.

Conclusions

Coordination is the management of interdependencies between actors, activities and resources in an enterprise. The number of actors, their properties, and the number and type of relationships between them may vary.

The performance of coordination depends on several factors:

- The interests, competence and commitment of the participating *actors*.
- The context where the interactions take place; cf. Figure 1.
- The *coordination technology,* i.e. the tools and procedures that define the opportunities and limitations for communication and cooperation.

In *PAKT* we realise that these elements can not be understood independent of each other, and that coordination in the real world can only be understood by considering the elements as mutually dependent. An implication is that a scientific approach with the objective of creating generic knowledge of coordination assume a multi-disciplinary competence from information technology to social science, and including engineering skills in bringing the knowledge into operations for changing the world.

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An informal requirements analysis of Norwegian public administration relative to CSCW

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Abstract

There is a rich potential for exploiting CSCW in public administration. CSCW does, however, sometimes provide possibilities for administrative work that do not necessarily fit with the laws and rules for how public administration is supposed to perform its duties. There are issues related to public access to documents produced or stored by the administration, privacy, security and political control.

The technology must of course be adopted to the context of public administration, but this requirement does not have infinite validity. A situation where public administration lags significantly behind in the use of technology is not sustainable. We should therefore expect conflicts to pop up, and there are reasons to expect adjustments to the laws and rules regulating the work of public administration.

Introduction

Work on Computer-Supported Co-operative Work (CSCW) addresses ways of supporting group work through the use of computers. Electronic mail has become an archetypical example, but there are numerous other examples. The diffusion of CSCW into actual use is still in its infancy. There are some examples of unsuccessful applications (8,14). Studies of the introduction of applications of CSCW are beginning to appear: one example being Orlikowski' s study of the introduction of Lotus Notes in a consultancy company (21). Although some results are available, we still have a major job in finding out what kinds of CSCW are "useful" as well as to what contexts they appropriately fit.

Computing in public administration has been studied quite extensively. Kraemer at al. have made longitudinal studies of use of computing in American local governments (18), addressing managerial action as a key factor for explaining differences in use of technology. Danziger points out that the potential for supporting interorganisational co-ordination and decision making has not been realised (7), a point actually mentioned by Galbraith as early as 1973 (12). Levinson argues that information technology has been used more to achieve efficiency than effectiveness (20). Willcocks draws on experience from several research projects in the UK, showing how an alarming percentage of IT projects fail and how managers now increasingly ask for return from IT investments in public administration (30).

This paper is based on investigations of computing needs in Norwegian public administration (4, 26). The term public administration always refers to Norwegian public administration, and many of the results are specific to Norwegian or Scandinavian public administrations. The paper is based on investigations into computing needs and trends in Norwegian public administration. In a now completed project the R&D needs related to IT use in public administration were investigated (26). Later a pilot study on teletechnology in public administration was conducted, and a proposal for a larger project, Otello, was made (4). Otello is now an active project, being funded by the Research Council of Norway (Culture and Society) and by the six participating public authorities. In these projects a series of qualitative, semi-structured interviews with managers and case handlers in public administration have been performed. In Otello, working groups have been established in the participating authorities. The overall aim with this work is to answer questions like:

> What goals should we have regarding use of information and teletechnology in public administration? How to identify these goals for a given technology and what technologies should we try to exploit?
>
> What conditions should be fulfilled in order to use information and teletechnology to achieve goals like efficiency, service, (changed) localisation, organisations, and competence in public administration?

How should the work with such changes and such technology be performed in order to be as effective as possible?

The purpose of the paper is to go close to a specific, concrete context, and investigate the possibilities for IT in general and CSCW in particular within that specific context. Doing so, we will slowly learn what impact local conditions have on the requirements for and deployment strategies of CSCW. It is assumed that national and cultural differences may have an impact on what is appropriate computer-support. Attempts to draw conclusions on a more general level will be made.

The use of computers has proliferated in Norwegian public administration. Heretofore the predominant form of computing in public administration has been large information systems supporting the core activity of various authorities. Central examples are systems for the revenue authorities and the social security system. Recently, personal computing has spread quickly. Most clerks now have access to text-processing and, quite often, other applications like drawing tools, spreadsheets, etc.

Within Norwegian public administration there is no strong standardisation on hardware or software.[1] There are therefore many technical obstacles to integration between users and between applications. Moreover, many authorities struggle with outdated architectures and spend most of their development resources finding ways to convert to more modern systems.

This paper focuses on applications of CSCW which support informal group organisation. Attempts have been made to apply transaction costs theory to characterise work in CSCW along these lines; see, for example, Ciborra and Olson (5) and Sørgaard (25). This focus has been chosen because it addresses the kinds of computer support which are called for by public administration and by authors like Danziger (7). Moreover, the focus on support for informal group organisation will highlight areas where there is a possible conflict between what is technologically feasible and the rules and traditions of public administration.

Goals and needs

Public administration is subject to politically defined goals. In Norway some of these goals have been formulated by the Ministry of Administration:

> Public administration should be an administration which can be managed politically, which is efficient in its use of resources, which is adaptable to the

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[2] *A notable exception is the emphasis on OSI communication standards. Most recent acquisition of e-mail systems are X.400 compatible.*

needs of the society, and which provides service of the appropriate quality, neither too high nor too low (1).

Other generally accepted goals are (26):

- Decentralisation. Norway' s population is scattered in small communities. Public administration must be located so that it can serve this population and so that it does not contribute too strongly to continued centralisation.
- Improved co-ordination within administration: between administrative levels like state, county, and municipality, and between public administration and the rest of society. Moreover, different agencies should work together to achieve common goals.
- Flexibility. The society and its problems change constantly, and public administration should be able to adapt to new needs in a flexible way.
- Improved service to customers. Public administration is less "protected" than before, and it has to live up to the same standards as in other parts of the society with respect to service. Privatisation is, after all, an alternative, although privatisation currently is far from high up on the political agenda.
- Equality before the law.
- Protection of privacy. As computing proliferates in public administration, there are fears that information about individuals can be combined and used in unjustified ways.

Currently there are some political trends that will have consequences for public administration. Firstly the EEA[2] will have a strong impact on many parts of public administration (10), and this impact will become even stronger should Norway join the European Community. Contrary to what one might think, these trends include consequences for municipalities and not only for central government. The municipalities are going to handle most of the issues related to free movement of people under maintenance of various social rights. Secondly, after many years of increased budgets, there is little room for expansion in public budgets, and hence there will be little room for increased employment in public administration.

Within this context there is a rich set of possible applications of CSCW, especially if CSCW can contribute to improved inter-authority co-ordination, better flexibility, efficiency and effectiveness, and improved service to customers. Ways of achieving these goals will be discussed below.

Inter-authority co-ordination

Different authorities often have partially overlapping jurisdictions. A central example is the way transportation and agriculture interfere with environmental interests. There are of course administrative units responsible for the solution of conflicts that may arise, but typically these units are top-level administrative positions or politically elected councils which already have a lot to do. It is be desirable that a larger number of possible conflicts be solved between the authorities involved, and that political bodies focus on formulating general guidelines for how to find compromises between the conflicting interests. This is in many ways the problem of handling task uncertainty (as described by Galbraith (12)), and the solutions called for are those based on lateral processes rather than on vertical information systems.

This is an area where there is a multitude of possibilities for CSCW. Communication can be supported by electronic mail and conferencing systems, but lack of integration with different text processors may reduce the benefits of communication between different authorities. Sharing of tasks can be supported by electronic archives with suitable multi-user functionality[3] or by specialised facilities as proposed by Kreifelts et al. (19).

The costs and effort associated with meetings may be reduced by videoconferencing, as different authorities often are located in different parts of the country. Sweden relocated several public authorities in the beginning of the 70s. It was expected that teletechnology would prevent an increase in travel. In an evaluation of the relocation it was concluded that this expectation did not hold (28). We should therefore be critical to assumptions that travel costs can easily be reduced through use of telecommunications.

Conventional meetings (i.e. face-to-face) can be supported by electronic meeting support systems. Such systems are not considered in this paper.

Improving inter-authority co-ordination is not, however, an easy game. It is often in conflict with the classical culture in public administration, where people focus more on following the rules and staying within budget than on solving the case at hand or on achieving something with the money spent. Many initiatives by the Norwegian Government can be seen as attempts to deal with this culture; see, for example (2).

Flexibility

Lack of flexibility is a "classical" property of public administration and other large bureaucracies. The Norwegian Government is trying to deal with this through new kinds of management (goal-directed and less rule-based), more flexible budgeting, etc. There is thus a trend towards more autonomy at lower levels. We may therefore expect issues to be handled at the level and location where they arise (or are received), but perhaps in co-operation between various case-handlers with different experience and competence.

CSCW could support this trend by facilities which strengthen the groups at various levels in the bureaucracy. Support for group communication and task sharing will clearly be important. As cases are handled locally according to their specific nature, rather than strictly according to set rules, there will be a need for support for problem solving in groups. Ways of "distributing expertise" will also be needed. One way of supporting this could be facilities for window-sharing or screen-sharing (6, 13, 16). Such facilities make it possible for a clerk to seek advice from an "expert" in handling cases represented within a conventional computer system.

Efficiency and effectiveness

Efficiency is an explicitly stated goal for public administration. The number of tasks is growing, but the supply of resources will not grow at the same speed, if at all. Classically efficiency has been sought through rationalisation and large information systems, and there is general agreement that for example the Norwegian social security system simply

[2] *The European Economic Area, the "open market" between the European Community and the European Free Trade Association (EFTA) (with the exception of Switzerland) which is to be established in 1993.*

[3] *This is an area where ordinary computing needs to be extended with CSCW capabilities.*

would not work without the use of information systems. In later years the social security administration, the customs authority, and the revenue authorities have introduced new systems and as a part of that process achieved documented increases in efficiency. In all of these three cases the theoretical gain in efficiency was reduced by two factors: Firstly, the high number of small service points made it hard to implement a marginal increase in efficiency. Secondly, some of the resources were fed back to the authority in terms of new positions at higher levels of qualifications than the jobs made obsolete. The high number of service points arises because the social security system and the revenue authorities have offices in each municipality. There are approx. 450 municipalities in Norway, half of which have less than 5000 inhabitants. Changes in the municipal structure are hard to achieve, and technological alternatives to such changes are very interesting.

CSCW is not a technology for classical rationalisation, but support for communication, access to experts and advisors, videoconferencing, task-sharing and several other kinds of CSCW may contribute to increased efficiency by letting cases be handled where they are instead of being passed upwards in the hierarchy.

The focus on efficiency will remain strong. As stated by Willcocks and as our own ongoing research confirms, managers in public administration want return on investments (30). However, it is being increasingly recognised that efficiency alone is not a satisfactory measure for the performance of a public authority. Taking the revenue authorities as an example, it is extremely easy to reduce resource consumption in handling tax returns; the problem is to do it while maintaining quality and improving quality where there are possible gains to be found. A 1 % increase in tax received (effectiveness) is far more important than a 5 % reduction in resources spent by the revenue authority (efficiency).

The trend towards increased focus on effectiveness and quality may open up for increased use of CSCW in public administration. In the revenue authorities there is a large potential for increased effectiveness in implementing so-called "value-oriented case handling", a strategy where effort in focused on tax returns where there is a high potential for increasing tax received. Such a strategy requires changes in work organisation. In order to work in a network of many small service points, it is not possible to rely only on expertise in the local office. Cases should be transferred to or advice should be sought from other case-handlers in the network. CSCW may contribute to this by facilities for transferring cases, locating people with appropriate expertise, providing facilities like bulletin-boards for the description of problems and expertise, etc.

Improved service to customers

Improved service is of course a very general goal. Public administration is seldom associated with service, we often see it as a source of trouble (e.g., paying taxes). In spite of this difficult starting point, several authorities are working on improving their service to customers. Improved service is important for those who are dependent upon public administration, be they clients of the social security system or companies which want to invest in a new production plant.

To the extent that CSCW contributes to inter-authority co-ordination, flexibility, and efficiency and effectiveness, it may also support improved customer service. We may also think of computer-support for front line clerks, i.e. those who provide the "visible" service. This is, however, a situation which is difficult to support: Turner provides an example of an on-line system which results in more stress for the front line clerks than a batch system of low quality and reliability (29).

Legal issues

Work in Norwegian public administration is supposed to be performed in accordance with relevant laws, rules and regulations. Two essential laws are "Forvaltningsloven" (the law on public administration, laying down principles for how to deal with "cases"[4], how to justify decisions, etc.) and "Offentlighetsloven" (freedom of information act, determining who in the public has access to what documents, etc.). The latter law declares all documents in public administration to be public unless otherwise stated (the "unless" part is, of course, quite large).

Members of the public have a general right to search for and obtain information about the work of the administration. This right is typically exercised by the press. Members of the public, companies, and other legal subjects who have a case in an administrative body (like an application for permission to do something) have additional rights. They have the right of party-access to the documents pertaining to their case (the case-documents). This right of access applies under certain circumstances to correspondence between the relevant administrative body and other administrative bodies, but it does not apply to internal documents nor to documents made by subordinate bodies (these are considered internal). When a document is not per se subject to party-access, the factual information in the document should be made available to the party (15). Inter-ministry and inter-authority communication is normally written.

Rules regarding access have strong implications for how information is gathered and for how letters and other documents are archived. Informal communication, like phone-calls, is not subject to public- or party-access, but notes from such communication is. It is considered good practice to make such notes, and to file them in the case-folder. The introduction, or rather the proliferation, of telefax-devices in public administration has resulted in practices which are on the limit of what can be considered correct. In public administration ordinary mail is normally opened, entered in the mail log, and archived by clerks in the mail reception before the mail is distributed to the case-handlers. Telefax documents, however, arrive directly in the office or section of the case-handlers. Telefax documents will thus only be logged and archived if the case-handler sees to it. Experience has shown that the judgements of clerks in the mail receptions and of case-handlers are not the same, and hence we already have a situation where modern technology has had an impact on practice in public administration.

Were the rules regarding access to be obeyed strictly in design and use of electronic media the implications would be strong. The legal state of these affairs is, however, not entirely clear, since tapes, films, other audio-visual media, and electronic files are not included in the concept of case-document, and hence cannot be made subject to party-access (15). In a

[4] *Much work in Norwegian public administration is described as "case-handling". This is not perfect English terminology, but it is an important concept for Norwegian public administration.*

situation where computers proliferate, such limitations in party-access to documents cannot persist. In a set of general requirements specifications for computer-support for case-handling and management in government, attempts have been made to deal with this and related problems, and it is required that (24):

> When information is exchanged[5] through the transfer of official case-documents, the transfer should automatically go via the archives (the archive-function) and be made subject to ordinary archiving procedures. This applies to incoming as well as departing mail.
>
> The last-mentioned requirement must not prevent the tool for information exchange from being used for the exchange of personal messages without going through the archive.

This requirement may, however, have strong and unintended consequences, see section 4.1 below.

Problems

As argued above, there are many possible applications of CSCW in public administration, but there are also many reasons to be careful when expectations are stated. Several potential problems related to the application of CSCW in public administration are discussed below.

Support for informal communication

In a study of the use of e-mail, the Swedish linguist Kerstin Severinson Eklundh studied the language used and classified it as a kind of "oral" language (9). Feldman argues that an important characteristic of electronic mail is the low threshold for sending a message, and that distributions lists make it easy to send messages to a whole community of receivers, the sender need not know who is on the distribution list (11). Feldman uses this to argue that electronic mail provides support for the exchange of weak-tie messages: messages which would not have been sent if there were no electronic mail, which are between people which do not know each other beforehand, which are between people who have communicated more than once, and which are between people that are not physically proximate (11). Another consequence of the same property of the medium is the tendency to be informal and even oral, as found by Eklundh. Sproull and Kiesler argue that the reduced social context cues associated with electronic mail contribute to use of the medium for messages which otherwise would not be sent (27).

Pickering and King investigate the issue of weak-tie communication further, arguing that there are great differences between different organisations as to the perceived benefit of increased weak-tie communication (22). They argue that universities have very high benefit from electronic messaging systems, since a university department needs to cover a broad set of specialities while research requires critical mass within very small specialities. These two concerns are very hard to combine unless there are other means for the researchers to be part of a scientific community. Electronic mail, they argue, provide appropriate support for this communication need. The same argument goes for research labs with large international co-operation, as exemplified by the high-energy physics community. Using this argument we can find potential benefits for authorities with decentralised and dispersed service points. This does require, however, that it is acceptable to share tasks and distribute problems in a wider community of case-handlers than what is the case today. Such facilities could potentially compromise privacy, as is also argued by Berg (3).

Taken together these findings confirm the widespread impression that electronic mail is well suited for, and in fact encourages, informal communication, and hence also is important as support for informal organisation. Electronic mail is very suited for the exchange of small, informal messages, and they are often written in a very informal style.

Informal communication may, however, be in conflict with the rights of the public to be informed and to have access to documents in cases in which they are a part. Since electronic mail can also be used to transfer reports and documents, this medium may tend to blur the distinction between informal communication (by, for example, telephone) and formal communication (letters).

The rules regarding party-access and general public access and the requirements put down in the general requirements specifications (see section 3 and (23, 24)) imply that there must be made a very clear distinction between informal electronic mail that is not subject to party or public access, and formal electronic mail that goes via the archives and is subject to the same rules as written letters. Such a distinction may, however, be quite artificial, since we know that people mix different issues in the same message (observed by, for example, Feldman (11)) and that there is a continuum of message-types and not two clearly distinct classes. Enforcing the distinction between formal and informal communication may thus prevent many natural uses of electronic mail, and as a consequence slow down or prevent effective use of electronic mail in inter-authority communication. Any implementation of this distinction must force the users to make up their minds every time they are going to send a message. To equip a messaging system with the appropriate facilities is not hard, but to make this work in practice will be difficult. We will either see practice that deviates from the intentions of the requirement or practice that suffers from a drastic and to some extent artificial distinction.

The quoted distinction between formal and informal electronic mail is therefore a too narrow reimplementation of the procedures with paper-based communication, and serves as an illustration that administrative procedures will not remain unchanged by technology.

Interorganisational CSCW

The problems related to support for informal communication are especially severe when considering interorganisational CSCW. Exchanges between different administrative bodies should normally be written, entered in the mail log and archived, etc. Thus such exchanges should be formal, irrespective of medium.

At the same time, much of the need for CSCW in public administration has to do with improved inter-authority co-ordination. This calls for better ways of co-operating across organisational boundaries, creating projects and relations of co-operation between people in different organisations. This will in many ways require a more informal style of work in inter-authority co-operation, as is customary in project-groups.

Within Norwegian public administration there is therefore a challenge in striking the right balance between adherence to formal rules for inter-authority communication and organising inter-authority co-

[5] *I.e. when e-mail is sent.*

operation in a sufficiently problem-oriented way. Traditionally physical distance and other context cues (like the cost of arranging a meeting) have kept the volume of close inter-authority co-operation down. Attempts to introduce CSCW in public administration will inevitably face this conflict. This may lead to requirements that are hard to meet (like the quoted requirement from (23, 24)). Another possible consequence is that the technical changes and derived reduction in the costs of inter-authority communication and co-operation will highlight various other kinds of resistance to such changes. We may thus experience that some actors start pursuing counterimplementation strategies (17) because they fear that the proposed technology changes "territories" and power bases.

Members of inter-authority committees whom I have interviewed have stated that a major problem has been the lacking willingness of some committee members to go beyond the scope of their own administrative body in dealing with the problem at hand. Computer support for committees and projects may remove location and travel as practical obstacles to this kind of work, only to disclose that there are other and deeper problems in making the co-operation go smoothly.

Reuse of data

One important area of possible gains of inter-organisational computing in public administration is the exchange and reuse of data. This can be done independently of CSCW, but CSCW across organisational boundaries will create a push for general exchange of data, since it will make differences in data, definitions and interpretations more visible.

Privacy

The privacy of individuals can be compromised by such exchanges of information. There are therefore strict rules for such exchanges, and these rules can conceivably come in conflict with many obvious uses of CSCW (for example an electronic letter from one authority to another containing extracts of information from internal databases, or a desktop conference where participants from several authorities sit in their own offices and share applications belonging to one authority). Thus CSCW use may be seen as a threat to privacy.

Quality of data

Moreover, the differences in data-definitions, meaning of data, quality of data, and reasons for collecting data will pose strong limitations for how data can be reused. This will be felt in many kinds of inter-authority CSCW, and this will create a "need" for stronger standardisation of the use of data, thus mixing CSCW up with large-scale attempts at streamlining public administration.

Incentives

In her study of the introduction of Lotus Notes, Orlikowski discusses several issues, one of them the lack of incentives to share data in the organisation she studied (21). In that organisation these problems were rooted in high competitiveness between the consultants and in lack of control of who uses the information made available to others. The latter point has to do with social context of passing a report onto somebody else. When that context is removed, there is an increased risk that the information is misinterpreted in an unfortunate way.

In public administration there is a need to be able to document the reasons for decisions. The use of shared documents and data in making decisions may therefore pose problems in terms of who is accountable for the decision. If we were to experience that a case-handler who had made some document available to others was made responsible for a decision he or she otherwise had no control of, the incentives for sharing data would clearly diminish drastically.

Security and authorisation

Today, the protection mechanisms in networks and systems are considered unsatisfactory by authorities possessing data of high sensitivity (health) or which could be subject to fraud (the revenue authorities). Such authorities are therefore inclined to refuse to connect to the same networks as other authorities, clearly making inter-authority CSCW hard.

The solution will have to be found in providing higher levels of security and authorisation, thus making many kinds of interconnection subject to control, logging, authorisation by password and other mechanisms, etc. This may, through this process of formalisation, result in obstacles for the use of CSCW to support informal organisation, simply because the informal contacts must be materialised in access rights and other explicit expressions.

Control over DP

Today, control over data processing (DP) in Norwegian public administration has been delegated to the different authorities. It is up to each authority to find solutions which fit its specific needs. This delegation of responsibility has also been seen as desirable for the successful uptake of IT: the different authorities should see DP as a part of their ordinary work. As an unfortunate result, co-located branches of different authorities may have totally incompatible solutions. Such incompatibilities may make even the simplest kind of inter-authority CSCW hard.

As a result, the dissemination of CSCW gets mixed up in a discussion of where the locus of control over DP should be. This is a highly political game, with many actors and many interests involved.[6] One issue is the establishment of a common infrastructure. Such an infrastructure is about to be defined ("Infrastrukturprogrammet"), but to get it implemented requires sufficient authority at a central, co-ordinating level. Moreover, there is a need to find ways to pay for this infrastructure. Until now each authority has paid its own DP-expenses. It will be hard to reach agreement about how to split the costs of a common infrastructure. This can possibly be dealt with by central subsidies to such infrastructure, so that each authority will have economic incentives for adherence to established standards.

Political control

In a democracy, political control over public administration is a central objective. One way to achieve this is the use of a strong hierarchy within each authority. CSCW is associated with autonomy and a focus on lateral instead of vertical integration, which may lead to the development of subcultures and informal networks that are hard to manage. Management by formulating goals is one solution to this problem, but this solution may in many cases conflict with political desires to be able to dictate solutions in specific cases.

Conclusion

The exploitation of CSCW in public administration will not be easy. The implications and assumptions of CSCW may be in conflict with the tradition and context of public administration in several ways. Most of these problems are related to the use of CSCW for the support of co-operation between different authorities.

These problems are not created by CSCW, they are problems in the structure of public administration itself, where some goals call for strict hierarchical control (i.e. political control, equality before the law), while others call for distribution and delegation of power (i.e. inter-authority co-ordination, effectiveness, flexibility). In this way CSCW highlights the contradictions in sticking to traditional rules and values of public administration on the one hand and the need to exploit technology effectively and efficiently on the other hand. The case has been made that CSCW technology is associated with assumptions about organisational practice, and that the validity of these assumptions differs between sectors and countries.

It is not obvious how one should handle the contradiction between CSCW-possibilities (and other possibilities) and administrative practices. One position is that technology should not be allowed to influence administrative practice, and that the adoption of technology should be entirely demand driven. The strength of such a position is that it emphasises that politics comes before technology, and that there is no technological determinism for the development of public administration.

I claim that this position is not sustainable for two reasons:

- It fails to recognise that CSCW and other technologies can change the relative benefits of different ways of organisation to such an extent that previous practices become so much less efficient and effective compared to what is possible that the differences become politically unbearable. If the private sector were to demonstrate significantly better or cheaper organisation than public administration, the forces pushing for privatisation of various public authorities would grow much stronger than what they are in Norway today.
- There is some flow of employees between the private and public sectors. Moreover there is essentially only one school system. The differences in qualifications demanded in the two sectors cannot be too big. This could create a situation where jobs in public administration became comparatively much less attractive, with strong consequences on the quality of recruited personnel.

For these reasons I claim that public administration is subject to a limited kind of technological determinism, that technologies which enable radically better or cheaper ways of organising the administration will win through. The associated changes in practice will not be without conflict, and we will probably observe that changes in practice will transpire faster than changes in corresponding laws, rules and regulations.

[6] *As an example, the central administration, i.e. the ministries, is currently being equipped with electronic mail. There has been disagreement about the choice of mail-system (should it be based on X.400 or is it sufficient with an X.400 gateway?). Ministries which already have installed e-mail are not interested in replacing their current systems; they argue that the internal use is more important and that the integration with applications like word processing is a critical issue.*

Acknowledgements

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International Information Infrastructure:
social and policy considerations

BY DAVID HAKKEN

659.2

It is reasonable to assume that readers of Telektronikk are familiar with the possibilities for communication inherent in wide-band, wide-area telecommunication systems which integrate advanced forms of information technology. You are also likely to be familiar with at least some of the technical challenges which must be met if access to such "information infrastructures" is to become general, and you have no doubt thought about at least some of the social issues raised by the existence of such info-telematic systems. While the journal has done much to increase awareness of the technical issues, however, one can wonder if it has been as successful in regard to the social issues. My purpose here is to stimulate a more developed discussion of these social issues.

Despite years of technical and commercial interest, information infrastructures remain essentially embryonic. Recently, however, they have again drawn the interest of more general publics. I shall therefore begin by drawing attention to some recent events which help explain why. These recent events have taken place primarily in the United States, but they are therefore, perhaps unfortunately, of necessary interest to the rest of the world.

Second, I shall locate concern with these systems in relation to recent IT research and practices, particularly work which attempts to place technical issues in social context. Such contextualising, I believe, is essential if the opportunities to bring information infrastructures more fully to life – which are implicit in the recent events – are to be effectively grasped.

Third, I shall describe certain responses to the events which have been generated within the computing community, focusing again primarily on a US organisation, Computer Professionals for Social Responsibility. CPSR has mobilised its membership to intervene collectively in the US discussion of information infrastructure. I am largely in sympathy with the organisation's intervention, although there may be some issues with regard to which the intervention could be more developed. To highlight these issues, I shall examine the CPSR positions in relation to the information praxis referred to above. I conclude with a discussion of the national/international dimensions of information infrastructures, an issue of concern to me in my current comparative study of the social construction of computing in Norway and Sweden. The internationalisation of information technology, a matter recently alluded to by Norwegian Foreign Minister Johan Jørgen Holst as one of several factors weakening the sovereignty of independent national states, especially small ones, is an issue raised but not developed adequately by CPSR.

Politics and information infrastructure

Perhaps the events which have contributed most to public interest in information infrastructures are those involving Bill Clinton. In his campaign for the US presidency, Clinton promised to reverse the relative "benign neglect" of the US economy of the Reagan/Bush years by pursuing an activist economic policy. Once in office, Clinton has spoken frequently of the need for a national industrial policy. A component of this policy, perhaps the one most frequently discussed especially by vice-president Al Gore, has been the promise to develop a national "information highway," or National Information Infrastructure (NII). Not only is the NII a reversal of policy; it will have the impact of diverting federal funds from other science/-technology activities (superonducting supercollider? defence? medicine?). This means it is likely to encounter stiff opposition. Yet its centrality to the Clinton presidency ("It's the economy, stupid") is even greater given Clinton's inability in early 1993 to get even his modest stimulus policy through Congress.

While federal resources will continue to flow to other IT and telecom activities, the NII will clearly become the centrepiece. To be able to either anticipate its consequences or to assess its chances, it is essential to grasp that this is a policy to reach economic goals through supporting technological development, because it is believed that such development will service the private sector. In this regard, the data superhighway concept is not dissimilar from previous Norwegian IT plans. This means of course that it is subject to similar difficulties – e.g., it is hard enough to achieve technological success on its own, let alone economic success as well.

The second recent event to which I wish to draw attention is even more directly economic. As CPSR staffers Gary Chapman and Marc Rotenberg point out, the NII in the US is

> "a bandwagon for very powerful economic interests, including telephone and telecommunications companies, cable television operators, computer manufacturers, software developers, acolytes of an emerging 'computer culture,' and a wide variety of other people."

The stakes for the US economy have been ratcheted up by the recently proposed merger between Bell Atlantic (one of the "baby Bells" created by the breakup of American Telephone and Telegraph, an event which more or less created the academic discipline of telecommunications in the US) and Tele-Communications, Inc., the nation's largest cable TV company. If similar mergers were to take place throughout the country, it would mean in essence that both the organisational form and a physical means for a much broader band info-telematic network, one capable of reaching 95 % of US homes, would already be in place.

This possibility is perceived to have great potential for shaping information infrastructure world-wide. The British Guardian Weekly editorialises:

> "The future shape of the world's exploding multimedia industry (in which telephones, computers, videos, music, and data transmission converge) may well be determined, not just by Rupert Murdoch, but by a series of giant mergers now under way in the United States."

The Guardian goes on to suggest that, unless similar organisational development takes place there, Britain is in danger of falling behind in the information technology revolution, that such huge monopolies must be "sternly regulated to protect the consumer", and that such regulation must be global, "to undermine Murdoch's recent boast that, in the end, technology can get past the politicians and the regulators."

The social construction of technology

One need not accept the Guardian analysis completely to acknowledge that these developments justify the public attention now directed to general information infrastructures. Moreover, the highly politicised character of this attention has made it somewhat easier than in other circumstances to direct attention to at least some of the social choices which are necessarily part of their creation.

As described below, it is the hope of CPSR to intervene in this process of social choice or social construction, so that the range of interests and opinions participating in the discourse of choice is as broad as that to be conveyed, hopefully, by the networks themselves. It is certainly one of my intentions to support such intervention, but I also wish to contribute to its effectiveness. I referred above to recent developments in information technology praxis – by which I mean the range of theoretically-informed practices, and practice-informed theorising – which I believe offer an improved way to understand how information systems develop and therefore how intervention can be most effective.

One such type of practice, developing within IT itself, is based on the growing realisation of the need for broadening the frame of discourse beyond the traditional technical perspective of the natural sciences and engineering, to take the social aspect seriously into account in the system development process. Among the manifestations of this realisation are the increased interest in *Computer Supported Co-operative Work*, *Participatory Design*, *Prototyping & Iterative Design*, and *Open Architecture*, and similar practices. Each of these is in its own way a manifestation of the search for a better standpoint from which to think about how to create both effective and humane systems; indeed, how these two criteria, far from being in opposition, are strongly interdependent.

There are innumerable sources of this awareness to which one could draw attention. A very good case can be made for its greater centrality to the history of informatics in the Nordic countries, both theoretically, as in the Object Orientation of, e.g., Kristen Nygaard and the Collective Research Approach of scholars like Pelle Ehn, and in the praxis of numerous action research projects aimed at user involvement in system development. However one might characterise the "Scandinavian approach," surely it includes awareness of the basic sociality of the development process and a desire to take this sociality into account systematically and at multiple points in the system development process.

Equally important to the emergence of attention to the social aspect is a reflexive literature among information practitioners. There is something of a strong connection between Weizenbaum's *Computer power and human reason*, Lucas' *Why systems fail*, and Yourdon's recent *The decline and fall of the American programmer*. I am most aware of the American tradition in this genre, much of which seems stimulated by Rob Kling. There are doubtless similar traditions in other nations (e.g., Vallee in France) to which attention could be drawn.

Also important, it seems to me, is a stimulus from the outside, among social scientists and humanists. While far too many of them have been willing to accept the rhetoric of IT marketing (e.g., computer revolution, a technology-imposed total social transformation, etc.) uncritically, a growing group of scholars have tried to study the relationship of computing and society seriously. Wastell, for example, provides a useful summary of work among psychologists which transcends the individualising, dehumanising limitations of early work on "human factors." Some of my colleagues in anthropology have taken up my challenge to develop a practice of "culture-centred computing," one aspect of which is attention to what happens when computing is developed in different national contexts; I return to this issue below when taking up the challenge of "globalisation." Within philosophy, communications, and literary theory, some scholars have chosen to move beyond seeing the conjunction of IT and social change as merely a terrain for humanistic speculation into serious study of, for example, the correlation between the spread of word processing or LANs and the shape of discourse patterns.

Particular attention, it seems to me, needs to be given to developments within economics. Here, a commitment to "opening the black box" of technology – that is, the tendency in neo-classical economics to treat technology as an exogenous variable in economic models – has become increasingly part of the work of institutional economists. In their search for theoretical stances which provide alternatives to the extremes of Friedmanite, supply-side total preoccupations with market mechanisms, many economists have found inspiration in Shumpeter's conception of economic cycles being tightly linked to technology change-induced periods of "creative destruction." Seeping somewhat easily into political rhetoric, since economists are among those social scientists whose concepts are more sensitive to public policy debate, the Shumpeterian view becomes the strategy, as in the Clinton plan. Here, the point is essentially to accelerate the marginalisation of old technology, not just previous generations of computers but Fordist production in general, in the belief that this will result in a new period of economic expansion, which in turn will solve the problems of "the limits to growth." No wonder that Al Gore, with his commitment to the politics of ecology, is so committed to the NII.

In short, one can identify scholarship both "within" and "without" IT supportive of an approach to IT praxis which is less bound to technical issues alone. My point here has not been to assess this scholarship. Instead, I have tried to indicate something of the depth and breadth of the information base available to those who choose to intervene more actively and broadly in the creation of large infotelematic networks. Indeed, I believe that some general propositions about the nature of information systems and their development can be derived from this scholarship. One is that social and organisational innovations are at least as important as technical ones if such systems are to be developed successfully. A second is that the main strategic difficulty in developing such systems is finding the proper way to balance the needs of individual work groups for autonomy and space for self- and group-definition with the need for standardisation, protocols, etc. A third is that successful systems tend to follow an evolutionary, rather than revolutionary or teleological, development course.

Perhaps the simplest way to summarise these principles is to say that information systems now have a history, and that this history has to be taken into account in a fairly deliberate fashion if successful innovation is to take place. Consider, for example, the Internet and its now twelve million users around the world. Surely the practices – both advantageous and limiting – which have agglutinated around the Internet will have to be taken into account in the creation of any global info-telematic network. Similarly, the creation of such a network in Norway will have to come to terms with the heritage of Norsk Data, both the information practices, especially in the public sector, built on ND machinery and architectures and the fact that veterans of the Norsk Data experience continue to play important roles in the reproduction of Norwegian IT practices.

Shaping the NII: The CPSR perspective

Thus far, I have attempted to establish the following points: that a discourse over a particular technology, a broad information infrastructure, has taken on central significance recently in the United States, and that were one to desire to intervene in this discourse, whether individually, collectively as an organisation, or corporately as a society, one could draw on a substantial knowledge base which indicates how thinking about IT can be contextualised socially. In what follows, I look at an intervention based on such principles, that of Computer Professionals for Social Responsibility in the US situation.

A formally international but overwhelmingly US-based organisation of primarily professional workers within the IT industry, a kind of insurgent professional society, CPSR has something of a record of intervention in national IT policy discussions, especially in the area of personal security. CPSR succeeded, for example, in convincing Lotus to withdraw from the market a mass data base product. The organisation had some effectiveness in raising strong cautions about how effectively Reagan's "star wars" system could protect against software failure. More recently, CPSR intervention appears to have helped turn the tide of US public opinion against the desire of the US national security state to control all telecommunication encryption practices. CPSR is also active as a sponsor of professional conferences – e.g., Participatory Design, Directions in Advanced Computing, CSCW – often in conjunction with the Association for Computing Machinery and other "mainstream" professional groups.

Perhaps the key document for anyone wishing to understand the CPSR intervention in discussions over NII is its major position paper, *Serving the community: a public-interest vision of the National Information Infrastructure*. The culmination of a year's work by a CPSR task group, the paper begins by affirming the great economic promise of NII and the belief that NII will transform society. The thrust of CPSR's intervention, is thus to broaden the criteria by which NII will be evaluated, arguing that its benefits should be seen not only in economic or functional terms, but socially, in relation to democratic political values.

CPSR also presumes that the public interest values which it endorses, those articulated by a coalition called the Public Interest Roundtable, are widely shared. It is how these goals are to be realised which remains unclear. In regard to the Clinton proposals, CPSR is concerned about:

- whether NII will provide universal access
- if a small number of carriers/companies will dominate, controlling design and content
- if NII will emphasise commerce at the expense of communication
- if public access to government will become more rather than less restricted, and/or if NII will eliminate rather than expand public services
- if NII will provide vital public space
- if NII will adequately protect individual privacy
- if NII will restrict global communication, and
- if hardware choices will be made without adequate attention to software.

It is evident that, with perhaps the exception of the last item, CPSR concerns are in the policy rather than the technical arena. In line with their policy concerns, CPSR makes the following general recommendations to the Information Infrastructure Task Force convened by the Clinton administration:

- to consider the social impact of NII development
- to guarantee equitable and universal access to network services
- to promote widespread economic benefits
- to provide access to government services via NII
- to protect public space on the net, and
- to think globally rather than nationally.

Nonetheless, CPSR is still a professional body. As such, it also addresses the system development process, suggesting adoption of the following design principles:

- functional integrity throughout the network
- democratic participation in design and development
- attainment of full service to homes, workplaces, and community centres, as well as to major enterprises
- allowing all users to act as producers as well
- addressing privacy issues from the beginning
- adoption of open and interoperable standards
- encouragement of experimentation and evolution, and
- requiring high reliability.

Analysis of the CPSR intervention

The CPSR position paper, *Serving the community...*, presents developed, nuanced arguments for each of the concerns, recommendations, and design principles articulated. Taken as a whole, these items constitute a good starting point for discussion of general information infrastructures in any national context in which a private market is presumed to be a major mediator of system development. CPSR is particularly to be commended for placing the Internet experience, notably its decentralised governance, as the historical core of an evolving set of NIIs. Can these perspectives be taken as constituting a sufficient guide to the development of information infrastructures?

To understand both the strengths and the limits of the CPSR intervention in the NII discussions, one must place it within the context of the organisation's more general program for a particular kind of professional intervention, one at the level of national policy, in the social construction of IT. This may well explain, for example, CPSR's willingness to accept the primarily economic orientation of the NII, to act as if there is general agreement as to the goals of the initiative, and that disagreement centres on means of implementation. Similarly, the particular importance given by CPSR to security issues also follows at least in part from its previous campaigns, and its attempt to publicise progressive design criteria follow from its membership development/conference programs.

In short, CPSR chooses to work within the boundaries of "normal" professional association intervention in the US, albeit from a more general position than is normally the case. (Professional associations tend to be most agitated about the narrow self-interest of their members.) Suspicion of trade unionism, especially more activist and social-aware varieties, means that professional associations sometimes have more influence there than they do in more social democratic countries like Norway. By working within "the system," CPSR hopes to affect the NII from within. As "experts," professionals tend to carry more weight in public discussion, at least of more technical matters.

It seems likely, however, that without substantially more powerful allies, the CPSR intervention will have limited effect. As long as NII is seen as primarily an economic development, the call for having it equally controlled by "democratic values" will sound weak. Creation of the truly general NII which would be necessary for the CPSR criteria to be fully met, would probably mean casting NII as a much broader social initiative than a primarily economic one. Moreover, casting the issue more broadly tends in the long run to undermine the "expertise" on which the CPSR strategy depends.

It seems to me at least that another matter that CPSR takes for granted, that NIIs will transform society, is similarly questionable. The social science scholarship referred to above, as well as the reflexive literature within IT, both justify a somewhat sceptical attitude toward over-enthusiastic views of technological change, because, among other things, they tend to slide too easily into the promotional. The point is that NII may change society substantially, or it may not; it all depends upon how NII is implemented.

What I am suggesting is a somewhat broader, multidisciplinary perspective, one which draws IT practitioners and social scientists together into a more general critique of the things that are taken for granted in the US NII discourse. (I believe this would also come to include a critique of Shumpeterian economic, especially the necessity of "creative destruction," as well.) Such a broader critique would require a more extensive rapprochement between scholars from different professions, one which I would welcome.

International information infrastructure

In explaining its concern about NII from the point of view of globalism, the CPSR committee makes the following comment:

> "...there is some danger policy makers will use economic competitiveness or national security to justify restrictions on international traffic. While imposition of such restrictions may benefit a particular industry or special interest, it also runs the serious risk of isolating the United States from the international electronic market place, cutting us off from the enormous benefits that come from greater co-operation in this area."

Here again CPSR is to be commended for recognising the enormous implications of NII for globalism. At the same time, the comment locates itself from within an argument for US self-interest and assumes a shared national interest, in this case between US IT professionals and private sector developers.

My experience here in Norway has convinced me that another, more global perspective is at least conceivable. Indeed, it may well be the case that such national boundaries are the major impediment to development of general information infrastructures, that we can't have NIIs without having International Information Infrastructures.

Reading it as constituting such a commitment to internationalism is another, more generous interpretation of the CPSR position. My intention has not been to demonstrate the limitations of the CPSR perspective so much as to indicate some ambiguities and associated areas for further development. My ultimate goal is that consideration of these issues will further an international discussion of information infrastructures, one capable of integrating a concern with both technical and social dimensions. Whatever their shortcomings, the CPSR perspectives constitute a strong starting point for such discussion.

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Status

International research and standardisation activities in telecommunication

BY ENDRE SKOLT

006:654

The objective of Telektronikk's *Status section* is to keep our readers up-to-date about organisation, working procedures, latest results, contributors, future activities, etc. from international standardisation bodies and research organisations.

In this context telecommunication is grouped into 14 study areas – each having a separate rapporteur. The rapporteurs are all delegates from the Norwegian Telecom to relevant international organisations.

The first presentation of a study area contains an overall description. The following contributions will be more detailed and directed at specific study items.

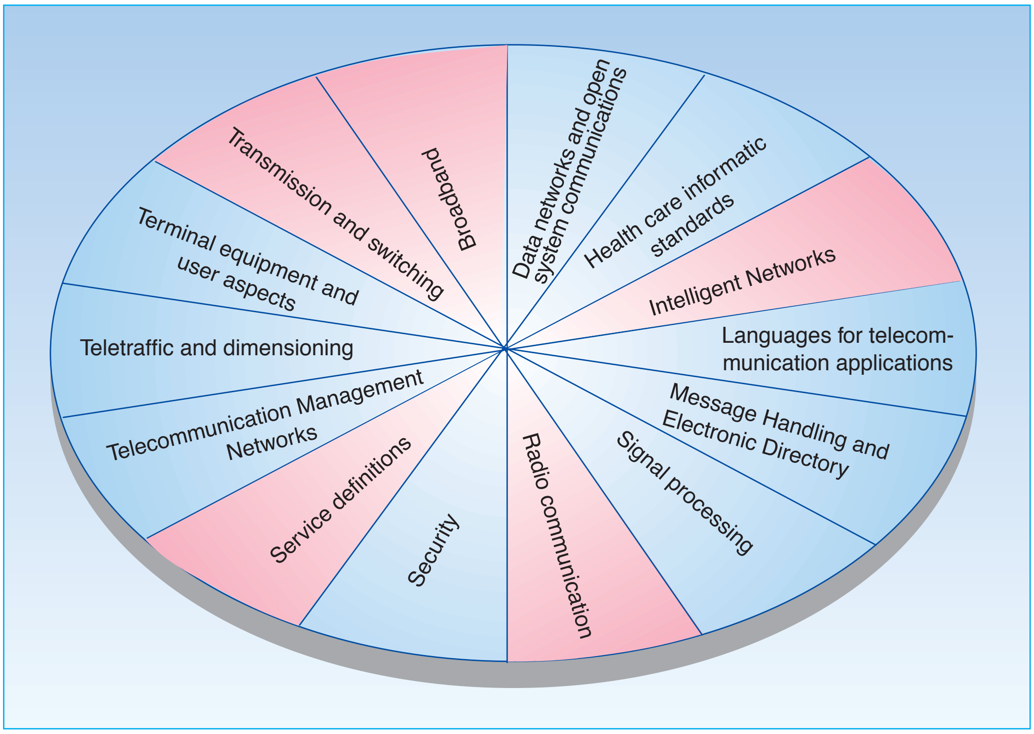

Figure 1 Telecommunication areas covered in this issue of Telektronikk

Table 1 Study areas and rapporteur

Study area	Rapporteur
Terminal equipment and user aspects	Trond Ulset
Service definitions	Ingvill H. Foss
Message Handling and Electronic Directory	Geir Thorud
Health care informatic standards	Sigurd From
Signal processing	Gisle Bjøntegård
Radio communication	Ole Dag Svebak
Intelligent Networks	Endre Skolt
Telecommunication Management Networks	Ståle Wolland
Languages for tele-communication applications	Arve Meisingset
Transmission and switching	Bernt Haram
Teletraffic and dimensioning	Harald Pettersen
Data networks and open system communications	Berit Svendsen
Security	Pål Spilling
Broadband	Inge Svinnset

This issue covers the following study areas:

- radio communication
- broadband
- intelligent networks
- service definitions
- transmission and signalling.

As a minimum we will report from standardisation activities in the European Telecommunication Standardisation Institute (ETSI) and the International Telecommunication Union (ITU). ITU has recently been through a re-organisation process and in an accompanied paper we outline the new administrative structure, give an overview of technical study areas and present a table with the questions to be studied in SG 1, SG 11 and SG 13 for the next three years. Other standardisation organisations that will be mentioned are ISO and CENELEC[1].

The administrative structure of ETSI has been described in Telektronikk 1/92.

In addition to giving reports from standardisation activities this issue covers telecommunication research activities in the following consortia, fora and organisations.

[1] *ISO: International Standards Organisation, CENELEC: Comité Européen de Normalization Electrotechnique.*

- RACE (Research into Advanced Communication in Europe), a research program sponsored by the Commission of European Community and initiated in 1987 with the overall objective 'Introduction of Integrated Broadband Communication taking into account the evolving ISDN and national introduction strategies, progressing towards Community-wide services by 1995'. Today, RACE initiates projects in a large number of study areas.

- EURESCOM (European Institute of Research and Strategic Studies in Telecommunication), a research institute established and owned by the Public Network Operators in Europe to promote their interests in the short, medium and long term time frame.

- TINA-C (Telecommunication and Information Networking Architecture – Consortium) started as a workshop in 1990, and is now formalised into a research study where all the large players in telecommunication and computing participate. The study areas are closely linked to intelligent networks (IN) and telecommunication management networks (TMN).

- ATM-forum, formed in 1992 in order to accelerate the deployment of ATM products and services by publishing specifications for implementations.

- COST (European Co-operation in the Fields of Scientific and Technical Research) conducts studies in system integration and assists standardisation bodies.

International Telecommunication Union (ITU) and standardisation

Introduction

Standardisation activities are a catalyst in the development of telecommunications and represent a collective effort of hundreds of millions of dollars every year. The objective is to ensure global compatibility of equipment and systems on a wide geographic area. This global interconnectivity and interoperability enable customers' choice of suppliers as well as lower costs through greater competition among manufacturers and service providers, and production of equipment on a larger scale.

Taking into account the large amount of man power that is spent in standardisation of telecommunications, questions have been raised whether the standard-setting organisations have been able to provide needed standards in a timely and efficient way. The answer is definitely no. A consequence has been the emergence of an increasing number of industrial de facto standards. However, the nature of standardisation is that decisions will always be based on compromise and therefor not represent the optimal technical solution.

The trend in standardisation today is to be more sensitive to market requirements, which implies more focus on prioritised services and turning away from a technology driven approach. The regulatory situation in telecommunication, open network provision, increased competition, globalisation, etc. have increased the pressure and need for standards. In response, the International Telecommunication Union (ITU), which has the overall responsibility for global standard-setting in the telecommunication area, has reviewed objectives, working methods, documentation, goals and has gone through a reorganisation. ITU has stressed that from now on, they shall provide results at a higher speed and with better quality.

In order to reflect this situation ITU has introduced specific measures such as:

- review of the organisational structure every two years
- creation of project management groups that will co-ordinate the work in the technology driven working parties.

The ITU is an intergovernmental organisation, within which the public and private sectors co-operate in the development of telecommunications and the harmonisation of national telecommunication policies. The ITU

- develops standards to ensure the interconnection of telecommunication systems on a world-wide scale regardless of the type of technology used
- adopts international regulations and treaties governing all terrestrial and space uses of the frequency spectrum as well as the use of the geostationary satellite orbit, within which countries adopt their national legislation
- foster the development of telecommunications in developing countries.

Every four years the World Telecommunication Standardisation Conference (WTSC), which represents the governing bodies of

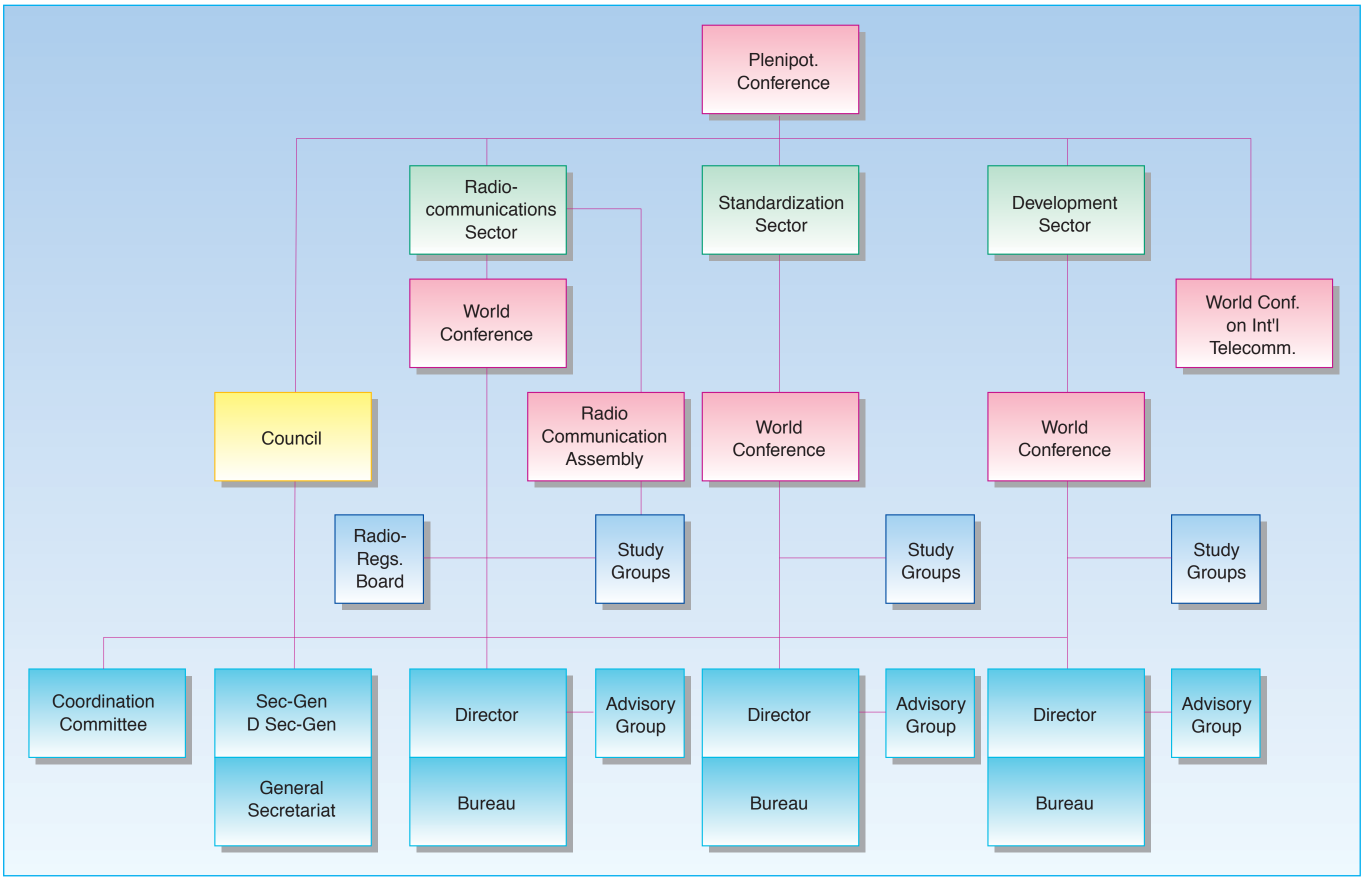

Figure 2 Organisational structure of ITU

the standardisation sector, concludes the result from the recent study period, i.e. to approve, modify or reject draft telecommunication standards, and approves the program of work on the basis of the proposals made by study groups. Earlier this year WTSC convened in Helsinki and approved more than 450 standards and decided on a work program for the 1993 to 1996 period. Among the adoption of more than 450 standards, the largest number belonged to the Q-series, which reflected the growing emphasis on networks, signalling and switching.

The conference also approved work programs for 15 Study Groups which will be meeting throughout the next three years. Although the work program comprises 289 Questions covering nearly every aspect of telecommunication, the main focus is on telecommunication services, operation and maintenance, network systems, tariff principles and accounting methods.

Contrary to standards produced in other fora, the ITU standards or recommendations are not binding. However, the nature of the standards is usually followed because it guarantees interconnection of networks. The recommendations are published in different series. The most common are as follows:

- E-series, numbering plans, traffic measurement, quality of service, performance
- F-series, telecommunication services
- G-series, signalling processing, coding techniques
- I-series, ISDN tele-, bearer-, and supplementary services, general network aspects
- M-series, management aspects
- Q-series, signalling, switching and protocols
- X-series, data communication, numbering plans, conformance testing methodology.

Organisational structure

In March 1993 the CCIR, the CCITT and IFRB[2] ceased to exist. They have now been replaced by the new ITU-TS and ITU-R. Together with ITU-D, they will make up the new technical organisation of the ITU. The trend is that all standard-setting activities of the CCITT and the CCIR will be transferred to the Telecommunication Standardisation Sector, however, at this point in time the separation of responsibility between the two groups are still under discussion. The rest of the CCIR activities have been integrated into a new Radiocommunication Sector along with the activities of the International Frequency Registration Board (IFRB).

Thus, from 1993 the ITU consists of a Plenipotentiary Conference (PC) which is the highest authority of the Union, the council which acts as the executive of the PC, world conferences on international telecommunications, a Radiocommunication Sector (ITU-R), a Telecommunication Standardisation Sector (ITU-

[2] *CCITT: International Telegraph and Telephone Consultative Committee, CCIR: International Radio Consultative Committe, IFRB: International Frequency Registration Board.*

TS), a Telecommunication Development Sector (ITU-D), and a General Secretariat (GS).

The ITU-TS

The new terms of reference for the standardisation sector is to study technical, operating and tariff questions and issue recommendations in those study areas in order to accomplish worldwide standards. The ITU-TS will also study interconnection of Radiocommunication systems in public networks and performance needed for these interconnections. However, technical and operating questions specifically related to Radiocommunication will be handled by the Radiocommunication sector. Every four years a world telecommunication standardisation conference will be held in which the work done will be reviewed. However, if a study group decides unanimously that a recommendation is urgent, it can be approved outside the world conference by a majority vote. This is referred to as the accelerated approval procedure.

The study areas in a study group are listed as questions. For each question there is appointed a rapporteur who is responsible for the content of the documents. The role of the rapporteurs is technical, and their appointment is based on expertise in the subject. In Table 3 we have shown the questions in SG 1, SG 11 and SG 13.

Table 2 ITU-TS Study Groups 1993–1996
(Study Questions of the Study Groups in shaded boxes are given in Table 3)

Study Group #	Name and description	Chairman
Study Group 1	Service Definitions	M. Israel (Canada)
Study Group 2	Network operation	G. Gosztony (Hungary)
Study Group 3	Tariff and accounting principles	B. Rouxeville (France)
Study Group 4	Network Maintenance	J. Shrimpton (United States)
Study Group 5	Protection against electro-magnetic environment effects	G. Meineri (Italy)
Study Group 6	Outside plant	K. Nikolsky (Russia)
Study Group 7	Data networks and open system communications	H.V. Bertine (United States)
Study Group 8	Terminals for telematic services	W. Staudinger (Germany)
Study Group 9	Television and sound transmission	Not yet appointed
Study Group 10	Languages for telecommunication applications	O.F. Faergemand (Denmark)
Study Group 11	Switching and signalling	S. Kano (Japan)
Study Group 12	End-to-end transmission performance of networks and terminals	P. Lorand (France)
Study Group 13	General network aspects	B.W. Moore (United Kingdom)
Study Group 14	Modems and transmission techniques for data, telegraph and telematic services	K. Kern (Germany)
Study Group 15	Telecommunication Standardisation Advisory Group (TSAG)	B. Horton (Australia)

The ITU-R

The CCIR activities relating to the efficient management of the radio-frequency spectrum in terrestrial and space radio communication have been integrated into a new Radiocommunication Sector. Every second year a radio communication assembly will be held in order to provide the technical basis for the work on world radio communication conferences, and approve the program of work of radio communication study groups. The focus of study will be on the use of the new radio-frequency spectrum in terrestrial and space radio communications, the characteristics and performance of radio systems, the operation of radio stations and the radio communication aspects of distress and safety matters.

References

1 *Telecommunication Journal*, May 1993.

2 *Telecommunication Journal*, February 1993.

3 ITU Press Release, 12 March 1993.

4 ITU Press Release, 23 February 1993.

5 ETSI. *Status of the stage 1 descriptions of the MoU services and other documents*, September 1993. (ETSI STC NA1.)

6 Kano, S, NTT Japan. Letter to Study Group 11 Member Organisations, March 1993.

7 ITU-TS SG 13, SG 13 Rapporteurs, Temporary Document 45, July 1993.

Table 3 Question in SG 1, SG 11 and SG 13

Q#	SG 1	SG 11	SG 13
1	Bureau services	Information Flow	Network capabilities for networks other than B-ISDN
2	International telex service	Signalling networks	Network capabilities for support of B-ISDN services
3	Further evolution of the international telex service	Protocol architecture	Network capabilities for the support of multimedia services in 64k-ISDN & B-ISDN
4	Development of PSTN-based telecommunication services	SS7 Management	Network requirements for B-ISDN signalling
5	Computerised directory assistance	IN long term architecture	ATM Layer
6	International telecommunication charge and service	IN Capability Sets	ATM adaptation layer
7	Universal personal telecommunication (UPT)	Signalling requirements for UPT	Requirements OAM and network management in B-ISDN
8	Mobile/personal telephone, telegraph, telematic, data and audio-visual services	Signalling requirements for mobile	Interworking of B-ISDNs with other networks
9	International multipoint communi-cation services via satellite	Signalling requirements for new transmission equipment	Interworking of ISDNs with other networks
10	Telefax services	Signalling requirements for B-ISDN	B-ISDN resource management
11	Enhanced facsimile service	Application of stage 2 to OA&M	ISDN Frame Mode Bearer Service (FMBS)
12	Message handling service	DSS1 L2	Refinement and enhancements to Layer 1 64 kbit/s-based ISDN Recommendations
13	International public directory services	DSS1 LS conformance	Refinements and enhancements to B-ISDN customer access recommendations
14	International public data transmission services	SAAL	Functional characteristics of interfaces in access networks
15	Common components for docu-ment communication services	DSS1 L3 protocols	ISDN architecture and reference models
16	Videotex service	MTP	General performance issues
17	Human factors issues arising in more than one service	SCCP	Availability performance
18	Human factors aspects of voice and non-voice services using public terminals	TC	Security performance
19	Human factors in telecommuni-cations not specifically related to new services	SS7 Lower layer testing	Error performance
20	Audio-visual multimedia services	SS7 reliability	Performance for ISDN connection processing
21	New services for broadband ISDN	SS7 call control protocols	Network synchronisation and timing performance
22	Enhancements to existing services due to ISDN capabilities	B-ISDN call control protocols	UPT performance
23	The suitability of new services to meet the needs of users	Signalling interworking	Transport network architecture
24	New services for the ISDN	Functional definition of digital exchanges	Network applications of SDH
25	- - -	Definition of managed objects	NNI and transport network interworking principles
26	- - -	Protocols for remote operation for management	Vocabulary for general network aspects
27	- - -	Updating of Q-recs.	Support of broadband connectionless data service on B-ISDN
28	- - -	Definitions	Integrated Video Services (IVS) principles for B-ISDN
29	- - -	Methods and procedures for access and information secu-rity in use of network services	- - -

Radio communications

The research and standardisation activities within the field of land mobile telecommunications systems are focused at the Universal Mobile Telecommunications System (UMTS) and the Future Public Land Mobile Telecommunications System(s) (FPLMTS). UMTS and FPLMTS are intended to be synonymous systems, the first developed by ETSI, the latter by ITU-R. These are third generation systems and are planned for initial operation around 2000–2002. They will operate in the 2 GHz band, allowing global terminal roaming, at least for a limited set of services. UMTS and FPLMTS encompass both a land mobile component and a satellite component, thus facilitating the provision of global radio coverage. Key characteristics of UMTS and FPLMTS include:

- the incorporation of a variety of application areas, ranging from domestic cordless applications, through satellite applications and land mobile telecommunications applications, to high bitrate indoor business applications
- a high degree of commonality of design world-wide
- service compatibility with the fixed networks
- quality of service comparable to the fixed network
- use of lightweight, pocket-sized terminals world-wide.

UMTS and FPLMTS cover a wide range of study areas, including telecommunications services, terminal and user mobility aspects, network architecture, interworking aspects and network design, radio network design, propagation studies, radio receivers, radio interface specifications, cellular aspects and satellite aspects.

Second generation mobile radio networks, such as GSM, DECT, ERMES, JDC, D-AMPS[3] are in the process of being introduced around the world today. These systems will not be covered in this summary.

In this summary we present the situation in the land mobile telecommunication area and give reports on technical study areas, latest results and future work in the following research and standardisation organisations:

- International Telecommunication Union Standardisation Sector (ITU-TS)
- International Telecommunication Union Radiocommunication Sector (ITU-RS)
- European Telecommunications Standardisation Institute (ETSI)
- Research into Advanced Communications for Europe (RACE)
- European Co-operation in the Fields of Scientific and Technical Research (COST).

[3] GSM: Global System for Mobile communication,
DECT: Digital European Cordless Telephone,
ERMES: European Radio MEssage System,
JDC: Japan Digital Cellular,
D-AMPS: Digital-American Mobile Phone System.

ETSI

ETSI

Within ETSI, technical committee SMG (Special Mobile Group) has been given the responsibility of standardising UMTS. Late 1991, the sub-technical committee SMG5 was set up to carry out this task. SMG5 acts as the system architect for UMTS, and is therefore also an important forum for the co-ordination of research and standardisation activities related to UMTS in Europe. As a consequence, SMG5 also plays an important role in the co-ordination of UMTS and FPLMTS. The work of SMG5 is largely based upon progress made in RACE, COST and the ITU.

SMG5 currently puts its efforts into the production of a set of baseline documentation in the form of ETSI technical reports, which will serve as a basis for making crucial decisions with respect to the actual design and standardisation of UMTS at a later stage. These baseline documents cover most aspects of mobile communications systems, including services, network, radio, speech quality, data communications, satellite and security aspects. Additionally, SMG5 has produced a work programme (approved by ETSI/SMG in June 1993):

- ETSI TCR-TR 015 ‘Work programme for the standardisation of the Universal Mobile Telecommunications System (UMTS)’. This includes an outline of the baseline documentation, the standards documentation, the terms of reference of SMG5 and the milestones for the standardisation of UMTS. This document provides a useful overview of the UMTS standardisation process, and the complexity contained therein.

There is a large number of organisations and companies active in the standardisation work. Public Network Operators include Norwegian Telecom, Telia, Telecom Finland, Telecom Denmark, BT, Mercury, Vodaphone, DBP Telekom, France Telecom, PTT Netherlands, Swiss PTT, Telefonica de Espana S.A and Mannesmann Mobilfunk. The manufacturers are represented by most major European companies, including Siemens, Alcatel, Motorola, LM Ericsson, GPT, and Nokia.

The aim of SMG5 is to complete the standardisation of UMTS within the year 2000. Some of the main decisions concerning the service repertoire, network architecture and radio interface are planned to be taken during 1995–1996, thus facilitating detailed specification work in the following years.

ITU

Within ITU, RS TG8/1 acts as the FPLMTS system architect. However, significant work has been and will be done in ITU-TS, notably SG1, SG11, SG12 and SG15. In order to improve global co-ordination, between the land mobile component and the satellite component of FPLMTS, an Inter sector co-ordination group is expected to be established.

In addition to the organisations and companies mentioned as contributors to UMTS in ETSI, Telecom Australia, Telecom New Zealand, Regional Bell Companies, NTT, AT&T, US West, Omnipoint Corp., INMARSAT and INTELSAT have strong interest in the development of FPLMTS. Up till now ITU-RS TG8/1 has produced a set of framework documentation for FPLMTS. This includes CCIR recommendations 816–819, addressing the areas of FPLMTS services, network architecture, the satellite component and the needs of developing countries, respectively. Additionally TG8/1 has produced CCIR recommendation 687, which outlines the concept of FPLMTS. The documentation is however in a drafting state and is continuously being updated. Revised recommendations may therefore be expected in the near future. Three recommendations related to the radio interface of FPLMTS were approved by ITU-RS TG8 in October 1993:

- 'Spectrum consideration for implementation of FPLMTS in the bands 1 885 – 2 025 MHz and 2 110 – 2 200 MHz' (FPLMTS.RFRQ)
- 'Requirements for the radio interface(s) for FPLMTS' (FPLMTS.RREQ)
- 'Framework for the radio interface(s) and radio subsystem functionality for FPLMTS' (FPLMTS.RFMK).

Apart from the radio aspects ITU-TS is involved in all other aspects of FPLMTS. Currently there are no final results, but SG1 are expected to finalise recommendation F.115 'Operational and service provisions for FPLMTS' in the near future. F.115 addresses service objectives and requirements, teleservices and bearer services to be provided by FPLMTS, quality of service issues as well as services related to security and privacy requirements. SG15 has started work on 8 kbit/s and 16 kbit/s voice codecs, suitable for application to mobile systems. Due to the range of application areas and the modes of delivery, several voice codecs may be anticipated. However, a common global voice codec is essential for global roaming of speech terminals.

RACE

In RACE II a number of projects in the Mobile Project Line, notably MONET, ATDMA, CODIT, PLATON, MAVT and MOEBIUS, relate directly to UMTS. An important objective of these projects is to contribute their results into ETSI/SMG5, usually through the participating companies. That is, the research projects will propose possible solutions meeting the design requirements of UMTS. So far, no major results are available from the RACE II projects, but significant results are expected during 1994. Below is a brief summary of the most important RACE projects related to UMTS:

- R2007 Planning Tools (PLATON). The objective of the project is to produce a planning tool software for optimising the use of the spectrum for UMTS.
- R2084 Advanced TDMA mobile access (ATDMA). The main objective of ATDMA is to investigate the potential of time division multiple access to meet the UMTS requirements in spectrum efficiency and overall performance.
- R2020 UMTS code division testbed (CODIT). CODIT aims at exploring the potential for code division multiple access (CDMA) for UMTS. As such, CODIT and ATDMA address one of the crucial features of the UMTS radio interface, namely whether code division or time division will be used to provide radio access for multiple users.
- R2040 Mobile experimental broadband interconnection using satellites (MOEBIUS). The project aims at demonstrating typical emergency applications of a global mobile network, e.g. telecommunications support in remote areas where no fixed network is available for use. The kind of information to be exchanged includes voice, medium-rate data, still and compressed full motion video in an integrated multimedia scenario, at relatively low tariffs.
- R2066 Mobile networks (MONET). The main objective of MONET is to study and evaluate possible options in the network area for UMTS.
- R2072 Mobile audio-visual terminal (MAVT). The main objective of the project is to find a powerful video and audio coding algorithm for transmission of moving and still video in a mobile environment like UMTS, and to implement this on a demonstrator called MAVT.

COST

COST 231, Evolution of Land Mobile Radio (including personal) Communications, and COST 227, Integrated Space/Terrestrial Mobile Networks are the COST projects most relevant to the evolution of second and third generation mobile communications. The work of COST projects are directed towards research, and the aim is to evaluate system proposals and assist standardisation bodies. COST 227 will terminate its activity in April 1995 and COST 231 is planned to last until April 1996.

Intelligent Networks

Intelligent Networks (IN) is an architectural concept which aims to support all telecommunication networks (public switched network, broadband networks, data networks, mobile networks etc.). IN will ease the introduction of new services based on new capabilities and extended flexibility. The objective is to facilitate service and network implementation independent provisioning in a multi-vendor environment.

IN encompasses work in areas such as network architecture, telecommunication services, call modelling, communication protocols, service management, service creation, service interaction.

This summary presents the latest results, technical study areas, contributors and future work in the following research and standardisation organisations:

- International Telecommunication Union Standardisation Sector (ITU-TS)
- Telecommunication and Information Networking Architecture-Consortium (TINA-C)
- European Telecommunication Standardisation Institute (ETSI)
- European Institute for Research and Strategic Studies in Telecommunication (EURESCOM)
- Research in Advanced Communication in Europe (RACE).

ITU-TS

ITU-TS Working Party 11/4 is responsible for generating world wide standards on IN. The first work package on IN was finalised in 1992, containing a general description of the IN concept and IN Capability Set 1 (CS1). Documentation can be found in the recommendation series Q.120X and Q.121X respectively. The main study areas in CS1 have been the description of a call model, a functional network architecture and the Intelligent Networks Application Part (INAP).

The public network operators and their associated research institutes have taken an active role in the standardisation work, especially Bellcore, France Telecom, PTT Netherlands, SIP, BT, AT&T, NTT. The most dominant manufacturers have been AT&T, Northern Telecom, Alcatel, Siemens and Ericsson.

The work on the next capability set has started and is expected to be finalised in 1995. The objective is to produce a new set of capabilities every two or three years.

TINA-C

In 1990 the TINA Workshop was initiated by Bellcore (USA), BT (England) and NTT (Japan) as an open forum for discussing information networking problems with telecommunications and computing vendors from the research and development community. Three international workshops have been held and a result of these workshops has been the motivation to establish a formal research study – the TINA Consortium. The objectives of the TINA-C are stated as:

1) to define a telecommunications information networking architecture based on advanced distributed processing and service delivery technologies that will enable efficient introduction, delivery, and management of telecommunications and networks
2) to validate the effectiveness of the architecture through laboratory experiments and field trials
3) to promote the use of the telecommunications information networking architecture world-wide.

Initial architecture specification results are expected late 1994. Final specification deliverables are expected in 1997–1998. The results will continuously be fed into the standardisation process.

The technical work is carried out by a core team located in New Jersey, USA. Currently more that 30 companies from Europe, North America and Asia are represented in the core team. The work has been grouped into the following work areas:

1) Logical frame architecture (information modelling, object model, distributed processing environment)
2) Service specification, construction and service management
3) Management architecture and resource management
4) Portable reference implementation and world-wide demonstrator.

European Telecommunication Standardisation Institute (ETSI)

ETSI NA6[4] has the overall co-ordination role on IN matters in ETSI and instructs other sub-technical committees to specify standards in areas such as services and protocols. Since there is an agreement to aim for global standards, NA6 co-ordinates their technical study areas and workplan with the ITU's. Draft results in NA6 are contributed to ITU. However, in order to meet specific European interests, ETSI produces standards and technical reports with exceptions to ITU recommendations. The following CS1 technical reports are finalised in NA6:

- DTR/NA-60501 'Global Functional Plane for IN-CS1'
- DTR/NA-60502 'Distributed Functional Plane for IN-CS1'
- DTR/NA-60204 'Guidelines for CS1 standards'.

On Capability Set 2 (CS2) work has been under way for more than a year. Prioritised work areas are internetworking, service and security aspects and service management. NA6 has agreed on the target services for CS2 which can be found in the document DTR/NA-60902 'IN CS2 targeted telecommunication services'. During 1994 NA6 has planned several technical reports:

- DTR/NA-60301 'Interworking between IN structured networks for CS2'
- DTR/NA-60302 'Interworking between private networks and public IN-structured networks'
- DTR/NA-60401 'Enhancement of the IN distributed functional/physical architecture'
- DTR/NA-60402 'Enhancement of the IN call model for CS2'
- DTR/NA-60603 'Methodology for service description in an IN'
- DTR/NA-61101 'Service and Feature interaction, Service Creation, Service Management and Service Execution aspects'.

ETSI SPS3[5] has specified a European version of the CS1 Intelligent Network Application Protocol (core INAP). Core INAP was finalised mid-1993 and is published as a standard in ETS/SPS-3016.

EURESCOM

The two main IN related projects in EURESCOM are EU-P230 'Enabling Pan-European services by co-operation between Public Network Operators' IN platforms' and EU-P103 'Evolution of the IN'.

EU-P230's main objective is to describe and specify medium term network architectural solutions for the purpose of interconnecting national IN platforms and provision of pan-European services. The project was formally initiated September 1992 carrying out information collection from the partners on existing and planned IN-platforms and IN-supported services. The results can be found in the following two deliverables:

- High level description of the candidate pan-European services, Deliverable D01/1, November 1992
- An overview of national IN implementations, Deliverable D02/1, December 1992.

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[4] *NA6: Network Aspects Sub-Technical Committee number 6.*

[5] *SPS3: Signalling, Protocols and Switching Sub-Technical Committee number 3.*

The main part of EU-P230 started in April 1993 and the technical study areas is constituted by network architecture and interconnection, service description and harmonisation, service interaction, mobility aspects, and user aspects. All the major Public Network Operators participate; however, Italy, Netherlands, and the Nordic countries are the most active. Final results from EU-P230 are planned in December 1994.

EU-P103 was established to conduct research in the future IN architectures and services in relation to service provisioning. The project has partners from 15 Public Network Operators in Europe and was initiated late 1991. The first phase of the project which ended early 1993, focused on object oriented service provisioning, where service modelling, methods and languages, service creation and service constituents (building blocks) have been important subjects of study. The following list of documents represent important results in EU-P103 so far:

- Service Environment Model, Sub Task 1.5.1, Final Report of EURESCOM Project P103 'Evolution of the IN'
- Service Life Cycle Model, Sub Task 1.4.1, Final Report of EURESCOM Project P103 'Evolution of the IN'
- Methods and Languages. Sub Task 1.3.1, Final Report of EURESCOM Project P103 'Evolution of the IN'
- Service Constituent identification, description and categorisation, Sub Task 1.6.1, Final Report of EURESCOM Project P103 'Evolution of the IN'.

In 1993 the second phase of the project continues and the target is still to produce results in the area of service provisioning. Final results are expected late 1994. P103 will be closely linked to the TINA-C work (see above).

RACE

The Race Open Services Architecture (ROSA) project (R1068/R1093) in RACE has been closely linked to Intelligent networks. It started in 1988 and the aim was to specify an architecture for intelligent network services based on object orientation and open distributed processing. The ROSA project ended in 1992. The ROSA framework architecture has been used as input to TINA-C and to RACE II.

The SPECS project (R1046) ran in parallel with ROSA. Its task was methods for specification, implementation and reuse of software. The SCORE project (R2017) is a follow up of the SPECS project.

In 1992 the Service Engineering (SE) project line was launched as a part of RACE II. This is a collection of RACE projects in the areas of service engineering for advanced intelligent networks. The CASSIOPEIA project (R2049), which is an extension of ROSA, plays a co-ordinating role in the SE project line. CASSIOPEIA continues the definition of an Open Service Architecture (OSA). The SCORE (R2017) and BOOST (R2076) projects in the SE project line are focusing on service component models and service creation based on objects. Most major European telecom operators and several manufacturers are involved in the Service Engineering area.

References

1 The TINA initiative. *IEEE Communications Magazine,* March 1993

2 Object oriented IN service provision. *The Fourth TINA Workshop,* September 1993.

3 Report of the 10th meeting of ETSI STC NA6 Lisbon, July 1993.

Broadband

Availability of high capacity fibre optics and advanced switching technology make broadband service provision feasible at data rates up to 565 Mbit/s. This has resulted in a number of international research and standardisation activities in the context of B-ISDN (Broadband Integrated Services Digital Network) and ATM (Asynchronous Transfer Mode). ATM is a high speed packet switching concept that has been chosen by ITU-TS as the transfer mode for B-ISDN. B-ISDN is defined as a network that can support services requiring capacity greater than primary rate.

In this summary we focus on network architecture, interfaces, general network aspects and performance. Services, signalling, switching and transmission aspects of broadband communication are treated elsewhere.

The latest results, technical study areas, participating companies and future work in the following research and standardisation organisations are presented:

- International Telecommunication Union Standardisation Sector (ITU-TS)
- ATM Forum
- European Telecommunication Standardisation Institute (ETSI)
- European Institute of Research and Strategic Studies in Telecommunication (EURESCOM)
- Research into Advanced Communications for Europe (RACE).

ITU-TS

The standardisation of B-ISDN within ITU-TS is mainly done in SG 1, SG 11 and SG 13. Results from SG1 and SG11 will not be mentioned here since that will be covered elsewhere.

In the Matsuyama meeting in 1990 SG 13 produced a release plan for B-ISDN. Three releases were planned. The first one by 1992, the second by 1994 and the third by 1996. Release 1 includes a wide range of study areas such as B-ISDN infrastructure, protocol reference model, general service and network aspects, UNI/NNI interfaces, ATM layer specification, ATM adaptation layer specification, traffic and congestion control, performance aspects, OAM principles of B-ISDN. Several recommendations on release 1 have been completed and approved. The following recommendations are available:

- Functional characteristics (I.150)
- General network aspects (I.311)
- Functional architecture (I.327)
- Performance (I.353, I.356)
- ATM layer specification (I.361)
- ATM adaptation layer (I.362-363)
- Traffic and congestion control (I.371)
- Reference configuration for UNI (I.413)
- UNI physical layer specification (I.432)
- OAM principles (I.610).

Some of these recommendations will be enhanced to cover all capabilities of release 1.

Studies of capabilities for release 2 are in full progress. Release 2 will include capabilities such as Variable Bit Rate (VBR) services, statistical multiplexing, different Quality of Service classes, multipoint connections, multiconnection calls, separation of call and connection.

The most active companies in the standard setting process in ITU are France Telecom, AT&T, NTT, BT, DBP, Telecom Australia, Bellcore, Bell Northern Research, Bellsouth and Siemens.

ATM Forum

ATM Forum was formed in 1992 as a group of local network suppliers, computer manufacturers, public network operators, research institutes and users. The reason for establishing the ATM forum was to accelerate the deployment of ATM products and services by publishing specifications for implementations. These specifications shall be based on existing standards and the focal point is on interoperability between manufacturers' equipment. The ATM Forum convenes every month.

In addition to interoperability aspects important study areas are User-Network Interfaces, physical layer and ATM layer, signalling, traffic management and quality of service. The results so far have been published in a series of specification documents:

- ATM Forum 93-215 (R8) Broadband Interconnection Interface (B-ICI)
- ATM Forum User-Network Interface 3.0
- ATM-Forum 93-590 Data Exchange Interface.

Specifications on traffic management and quality of service are expected next year.

An updated version of the B-ICI specification will be completed by the end of 94.

In the ATM Forum Bellcore, AT&T, IBM, Siemens, MCI Communications, Synoptics, Northern Telecom, BBN Communications, Alcatel, Adaptive, Sun Microsystems are the most active and influent partners.

ETSI

The standardisation of B-ISDN within ETSI is mainly done within sub-technical committees NA4 and NA5. The results are published as European Telecommunication Standards (ETS) and European Telecommunication Reports (ETR).

The workplan in ETSI is much the same as for ITU-TS as most of the ETSs are ETSI endorsements of ITU-TS recommendations with European exceptions.

NA4 is responsible for performance aspects and NA5 acts as the system architect and covers study areas such as network architecture, network operational aspects, ATM layer and ATM adaptation layer specification, protocol reference model and traffic engineering. The following publications are available:

- DTR/NA-52106, 'B-ISDN principles'
- DTR/NA-52204, 'Parameters and mechanisms provided by the network relevant for charging in B-ISDN'
- DE/NA-52209, 'B-ISDN OAM principles and functions'
- B-ISDN ATM Adaptation Layer Specification (type 1 and 3/4, DE/NA-52617 and 52618)
- DE/NA-52729, 'B-ISDN Protocol Reference Model and its applications'
- DE/NA-42119, 'B-ISDN ATM Layer Cell Transfer Performance'.

In addition reports on the following subjects will be finalised late 1994: Numbering, addressing and routing aspects in B-ISDN, B-ISDN management architecture and management information model for the VP-VC crossconnect, functional description of B-ISDN network elements, B-ISDN ATM Adaptation Layer Specification (type 5), ATM Adaptation Layer type(s) for the support of video and multimedia services, requirements for traffic control and resource management for VP/VC cross connected networks, retainability performance for B-ISDN connection types, availability and retainability performance for semi-permanent
B-ISDN connection types.

France Telecom, BT, DBP Telekom, Royal PTT Netherlands, Telecom Portugal, SIP, STET and CSELT Italy, Siemens AG, Alcatel CIT and Ellemtel are the most active companies in this work.

RACE

The RACE program started in 1987 with the overall objective 'Introduction of Integrated Broadband Communication taking into account the evolving ISDN and national introduction strategies, progressing towards Community-wide services by 1995'. The activities (projects) are performed under contracts signed by the Commission of European Community and consortia of organisations. The projects produce yearly progress reports as well as technical reports.

The first phase (RACE I) was completed at the end of 1992 and the second phase (RACE II) was set forth during the first part of 1993. The RACE program plans completion by the end of 1995.

The following is a list of projects and results from RACE I:

- R1014 ATMOSPHERIC: This project has elaborated evolutionary network architecture.
- R1022 Technology for ATD: The objective of this project was to define and develop a set of ATM components together with a technology testbed to demonstrate the viability of the concepts.
- R1044 IBC Development and Implementation Strategies: This project has produced a common functional specification, functional models, reference configurations, definition and description of new services and possible evolutionary paths.
- R1049 ATM concept: This project has studied the ATM layer protocol, an ATM signalling concept, connectionless services and has developed a protocol reference model.
- R1081 BUNI: The objective of BUNI has been to produce hardware for interfaces at the broadband T reference point (TB) and assist in the development of a common standard.
- R1083 PARASOL: This project has produced a set of requirements and measurement methods to support introduction of ATM. It has developed an ATM Traffic Generator and an ATM Traffic Analyser to assist in integration tests of other RACE projects.

In RACE II the below list of projects bears reference to broadband:

- R2016 STRATOSPHERIC: This project will develop a 34 Mbit/s PDH/ATM mapper and evaluate introduction strategies for broadband. It will also design, implement and test a string mode algorithm and a high speed switch for investigating the potential for increased network efficiency.
- R2032 COMBINE: This project will investigate the interworking of ATM networks with other networks to enable separated ATM networks to work together via other interconnecting networks.
- R2061 EXPLOIT: This project will provide an ATM testbed for experiments. The experiments will be performed with real traffic sources to validate theoretical models, particularly regarding Connection Admission Control and Parameter Control.
- R2081 TRIBUNE: This project is a follow up to BUNI and its objective is to provide a UNI testbed for third parties.

EURESCOM

EURESCOM's work with broadband started in 1991 with project P105: 'European ATM Network Studies'. The goal of this project was to produce deliverables as support for specification of a European ATM Pilot (Virtual Path (VP) crossconnect network).

The P105 project is finalised and the results are a major input to the specification of the European MoU Pilot Network planned to open mid 1994.

The specification of the European ATM Pilot has covered technical areas such as benchmark services, reference configuration, VP handling, protocol reference model, interworking, use of satellite, physical interfaces, protocols over the interfaces, performance, network management, charging and accounting, traffic and dimensioning aspects, routing, addressing and numbering, network evolution.

The project had 13 partners and all the major public network operators took part.

A new project, P302: 'European switched VC based ATM Network Studies' (VC = Virtual Channel) started in September 1993 as a follow up to P105. The intention of this project is to extend the studies to encompass VCs as well as VPs and include signalling.

Service definitions

The different standardisation bodies working on service definitions aim at describing the functionality of telecommunications services from a user point of view. In order to allow the same services to be implemented in different networks the service definitions should as far as possible be independent of the underlying technology. However, a wide range of services are defined for implementation in Public Switched Telephone Networks (PSTN) and Integrated Services Digital Network (ISDN), but there is a trend to gradually focus more on services and service definitions for implementation in Intelligent Networks (IN) and Broadband-ISDN.

Keywords in the area of service definitions are telecommunication services, bearer service, teleservice, supplementary service, service features and stage 1 description.

In this summary we will present work procedures, study areas, latest results and future work in European Telecommunications Standardisation Institute (ETSI) and International Telecommunications Union Standardisation Sector (ITU-TS).

ETSI

The work on service definitions is mainly done in sub-technical committee NA1. NA1 holds two annual meetings, in which the work is organised in three working parties.

Until 1992, NA1 focused mainly on MoU-services for ISDN. MoU (Memorandum of Understanding) is a binding agreement between network operators. Since the first set of service descriptions was finalised in 1992, new services have been included in the work programme. Along with additional services for ISDN, services which need support from the Intelligent Network (IN) concept are being described, and the number of this type of services is likely to grow, e.g. UPT – Universal Personal Telecommunications. Multimedia and broadband services are also subject for increased attention. Standardisation of new services for the PSTN, such as display services, are much debated.

The most active public network operators and associated research institutes are France Telecom, BT, PTT Research Netherlands, DBP Telecom, Telecom Denmark, Telia (Sweden), Swiss PTT, CSELT. Dominant manufacturers are Ericsson, Alcatel, GPT, Northern Telecom, and Siemens.

Descriptions of all MoU services have been finalised and most of them will be published as European Telecommunications Standards (ETSs). Some are now in a voting procedure[6]. The standards consist of supplementary services, bearer services and teleservices. Examples of supplementary services are call forwarding services, advice of charge services, presentation services and conference services. The list of bearer services and teleservices are given below.

Teleservices	**Bearer services**
Telephony 3.1 kHz	Packet mode X.31 case B-B channel
Telefax G4	Packet mode X.31 case B-D channel
Teletex	Circuit mode 64 kbit unrestricted
ISDN syntax-based Videotex	Circuit mode speech
Telephony 7 kHz	Circuit mode 3.1 kHz audio
Videotelephony	

In the future work much emphasis will be put on the service concepts such as UPT. Target date for UPT and most of the current draft standards is the first quarter of 1994. Table 4 shows examples of draft standards and planned approval dates.

ITU-TS

The work on service definitions in ITU-TS is mainly done in SG 1. The work is split into three working parties (WP):

1) WP 1 covers bureau services, international telex services, further evolution of the international telex service, development of PSTN-based telecommunication services, computerised directory assistance, international telecommunication charge and service, enhanced facsimile service, message handling services, international public directory services, telephone and messaging services, and GVNS

2) WP 2 covers audio-visual multimedia services, new services for B-ISDN, enhancements to existing services due to ISDN capabilities and new services for the ISDN

3) WP 3 covers Universal personal telecommunications (UPT), Mobile/personal telephone, telegraph, telematic, data and audio-visual services, international multipoint communication services via satellite, telefax services, international public data transmission services, videotex service.

In addition, a special working group has been established on human factors.

SG 1 holds two regular meetings a year. When necessary, interim rapporteurs meetings are held, discussing a limited range of services. One of the most important activities in the recent study period has been to enhance recommendations on 1988 service descriptions ('blue book'). Other areas that have had much focus is discussion on new service concepts such as UPT and GVNS. This work has been co-ordinated with a corresponding activity in ETSI.

Table 4 Examples of draft ETSI standards and planned approval dates

Document number	Title	Approval date
DE/NA-10009	Remote Control Service	February '94
DE/NA-10010	Universal Personal Telecommunication	March '94
DE/NA-10011	Universal Access Number	March '94
DE/NA-10012	Charge Card Calling	March '94
DE/NA-10013	Virtual Card Calling	March '94
DE/NA-10014	Premium Rate	March '94
DE/NA-10015	Televoting	March '94
DE/NA-10025	Automatic reverse charging on the fixed public telephone network	February '95
DE/NA-12240	Teleaction	February '94
DE/NA-12409	Base Document on Multimedia Services	February '94

Concerning development of PSTN-based telecommunication services the following results are expected in the next study period:

- E.117, Terminal Devices Used in Connection with the Public Telephone Service
- F.GVNS, Global Virtual Network Service
- New Recommendations on Guidelines for calling devices accessing the PSTN
- New Recommendations on the Home Country Direct Service
- Amendments to recommendation E.152 on the International Freephone Service
- A single standard for the placement of alpha characters on telephone keypads.

In the area of new services for broadband ISDN Table 5 shows the status.

The most active Public Network Operators associate research institutes are France Telecom, BT, DBP Telecom, NTT, CSELT, AT&T Bell Labs. Manufacturers with great impact are Alcatel, NEC, GPT, NT, Siemens, AT&T.

[6] *After a draft standard has been approved in the sub-technical and technical committee, it will be subject for a public enquiry review. Then the public enquiry review needs to be approved by the technical committee. At this stage the standard enters the voting procedure. ETSI pursues a unanimous decision, however, only 71 % of the votes are needed for approval.*

Transmission and switching

High speed digital transmission line systems and multiplexors, combined with computer controlled digital cross connects, is the basis for development of high capacity, self-healing and flexible digital transmission networks with software controlled configuration and supervision systems.

The development of digital transmission networks, digital access networks, digital switches and advanced signalling protocols is the basis for the new world-wide ISDN (Integrated Switched Digital Network), combining speech, video and computer communication services within one switched network. The signalling protocols are an essential resource for ISDN networks, and detailed international standardisation is necessary for signalling protocol compatibility between the networks. The ISDN signalling protocols are now also being extended to support B-ISDN.

This text contains a general summary of current status of important finalised recommendations and standards, and ongoing work per autumn 1993 in the International Telecommunication Union (ITU) and European Telecommunication Standardisation Institute (ETSI). Study areas covered are transmission media, transmission systems and networks, ISDN and B-ISDN switching and signalling.

ITU-TS

The standardisation of transmission systems and equipment within ITU is primarily done in SG 15.

Transmission media

A first set of some optical fibre and cable ITU recommendations has been available for some time. The quality of the recommendations is good enough to allow widespread deployment of cable in the transmission networks, with a long expected technical and economic lifetime. However, there is an important need to improve cable designs and plant engineering for optical cable in the access network because of the large investments required in this sector.

Development of new and improved recommendations is going on as a continuous process. Recommendations for passive optical components in the cable network are also being developed.

ITU recommendations within this field can be found mainly in the G.600-series, e.g. G.652 describes standard single mode fibre and G.653 describes dispersion shifted fibre.

Transmission systems and networks

Work on transmission systems and networks is mainly focused on SDH (Synchronous Digital Hierarchy). A reasonably stable set of recommendations for SDH transmission networks and network elements is now available in the G.700-series. First version of recommendations for SDH information models and system specific OAM aspects is available, but is not yet sufficiently mature to support compatible systems from different suppliers. A continuous work on improving SDH recommendations is going on, with special focus on OAM aspects.

Table 5 Approved and planned recommendations for broadband ISDN services

Rec. No	Title	Target date
F.811	Broadband Connection Oriented Bearer Service	approved 1992
F.812	Broadband Connection-less Bearer Data Service	approved 1992
F.310	Broadband videotex Services	1995
F.722	Broadband video telephony Services	1996
F.732	Broadband video conference Services	1995
F.821	Broadband TV distribution Services	1995
F.822	Broadband HDTV distribution Services	1996
F.MDS	Multimedia Distribution Services	1996
F.MDV	Multimedia Delivery Services	1996
F.SPVP	Semi-Permanent Virtual Path Services	1995

At the moment a technological basis for implementation of transmission systems with much higher capacity does now exist. However, work on ITU recommendations for higher capacity systems (more than STM-16) is in an early stage. Work on recommendations for access transmission networks is progressing, with development of standard interfaces to the exchange and new transmission system solutions for both copper and fibre. However, a satisfactory set of recommendations for access networks is not yet available.

Two study areas with specific importance should be mentioned:

- transmission systems and networks with computer controlled configuration and management qualities
- more advanced transmission systems and networks within the access network.

ITU recommendations in this field can be found mainly in the G.700-, G.800- and G.900-series:

- Recommendations G.707, G.708, G.709 describe the most important aspects of SDH interfaces and frames
- Recommendations G.782 and G.783 describe characteristics of SDH functional blocks and equipment

- Recommendation G.784 describes the SDH information model

Switching and signalling

The standardisation of switching and signalling within ITU is primarily done in SG 11.

Narrowband ISDN has now entered a phase of widespread and massive upgrading of the networks in industrialised countries. Stable recommendations for an international ISDN network with a limited set of services have been available for some time, and are now put into operation by network operators all over the world. A set of enhancements to ISDN signalling recommendations to support a wider range of bearer services and supplementary services, was finished in 1992. This enhanced version of ISUP ('version 2') is expected to be implemented by network operators from 1995 onwards. Work is continuously going on with improvements and additions, but the main part is now ready for implementation.

In order to support business communication, universal personal telecommunications and intelligent networks, some important additions and improvements to ISDN signalling recommendations are expected within the next 2–3 years.

'Version 1' of the ISDN network signalling on the international interface can be found in Q.767. The ITU Q.900-series (e.g. Q.931) describes access signalling. 'Version 2' of the ISDN network signalling is mainly described in the 1992 version of the Q.700-series (Q.764 and associated recommendations).

For the ISDN access signalling the 'version 2' is to be found in 1992 versions of Q.931 and associated recommendations.

Currently, available 'broadband ISDN' networks only exist as proprietary solutions, supporting computer communication services. The ITU version of broadband ISDN, supporting both narrowband telephony, broadband telephony and computer communication services, is still in a drafting state. Operational deployment of B-ISDN networks according to standard solutions is expected from 1996.

The 'release 1' B-ISDN is a new set of signalling protocols, which supports both narrowband ISDN bearer services, supplementary services and a broadband bearer services in one network. A set of 'release 1' broadband ISDN signalling recommendations will be completed by ITU at the end of 1993 / beginning of 1994. Improvements to 'release 1' B-ISDN signalling are expected to continue for some time.

Work on 'release 2' B-ISDN signalling is in a preliminary stage. 'Release 2' will probably be available from 1996. An important difference between 'release 1' and 'release 2' is that 'release 2' is designed to separate 'call' and 'connection'. A 'release 2' call could contain several connections.

The 'release 1' network signalling is described in the B-ISUP recommendation 'BQ.764' and associated recommendations. The access signalling is described in recommendation 'Q.93B'. Interworking between 'BQ.764' and 'Q.93B' is described in recommendation 'BQ.699'. Interworking between 'BQ.764' and narrowband ISDN Q.764 is described in recommendation 'BQ.6xx'.

Preliminary versions of the draft recommendations are available in ITU SG 11 meeting reports and temporary documents.

ETSI

Transmission

The standardisation of transmission systems and networks in ETSI are primarily done in the TM technical committee.

The work within ETSI is closely co-ordinated with ITU. Standards for optical fibre cable, transmission systems and transmission networks are based on ITU recommendations, however, with a higher degree of details.

Technical study areas in ETSI are closely co-ordinated with ITU.

A range of ETS/ETR documents are available as drafts or approved documents. Some of them are listed below:

- ETS 300 227 specifies standard single mode fibre
- ETS 300 228 specifies dispersion shifted fibre
- ETS 300 226 specifies fibre cable for ducts and buried applications
- ETS 300 229 specifies fibre cable for aerial applications
- ETS 300 147 specifies the ETSI version of the SDH frame and multiplexing structures
- ETS 300 297 specifies the digital section for ISDN Basic access
- DTR/TM 3002 specifies the line transmission and multiplexing systems for ISDN Basic access on metallic lines.

Switching and signalling

The standardisation of switching and signalling within ETSI is primarily done in the SPS technical committee.

The ETSI activities are closely co-ordinated with ITU and signalling standards produced by ETSI are closely aligned with ITU recommendations. ETSI proposals are input and discussed in the ITU, and the same technical experts often attend meetings in both organisations. A major part of the ITU recommendations are input from ETSI.

The following is a list of important achievements in the area of switching and signalling:

- ETS 300 121, 'Version 1' of the ISDN network signalling on the international interface
- ETS 300 102, 'Version 1' layer 3 of the DSS1 ISDN access protocol
- ETS 300 356, 'Version 2' of the ISDN network signalling (draft)
- ETS 300 102, 'Version 2' layer 3 of the DSS1 ISDN access protocol (draft)
- ETS 300 303, Signalling interworking between ISDN and GSM (public enquiry).

ETSI 'Release 1' B-ISDN signalling protocols standards seems to be identical to corresponding ITU recommendations.