Many voices, one structure

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ONE STRUCTURE

Inaugural lecture
by Prof. J. Arnbak

Engelse vertaling van de rede
"Vele stemmen, één structuur"
uitgesproken bij de aanvaarding
van het ambt van gewoon hoogleraar
in de tele-informatietechniek
aan de Faculteit der Elektrotechniek
van de Technische Universiteit Delft
op woensdag 8 oktober 1986
door dr. J.C. Arnbak.

Mijne heren leden van het College van Bestuur,
dames en heren leden van de Universiteitsraad,
mijnheer de Rector Magnificus,
dames en heren leden van onze universitaire gemeenschap,
en voorts Gij allen die door Uw aanwezigheid blijk geeft
van Uw belangstelling,
zeer gewaardeerde toehoorders.

A newly appointed professor is expected to deliver an inaugural lecture to representatives and friends of the academic society, thereby assuming its social graces. The word 'inaugural' reminds us of the solemn rituals of the Roman augurs, who in public foretold the future in a strictly ceremonial manner. Diplomatic protocol prescribes that an ambassador upon arrival in a foreign capital delivers his credentials to the Head of the receiving state, while observing an agreed etiquette. Similar structured patterns of approaching each other have been identified in completely unrelated animals by modern ethology. Apparently, such patterns serve to establish a secure mating relationship and to control aggression. Think of the exotic dances of cranes or the mocking fights of the three-spined sticklebacks.

These four examples of protocols are not mentioned to remind you that I stand before you as a new Delft professor, a Danish representative, a strange bird and a queer fish. It is useful to realise that all successful exchanges of individual information depend, to an amazing extent, on the availability of a common structure. Without access to accepted protocols, common codes and shared media, we would feel excommunicated: We could inform neither each other nor even ourselves. Paradoxical as it may sound, there can be no individual freedom of information without access to a collective order of communications. Hence the title of this lecture: Many voices, one structure. I shall attempt to discuss the present challenge to the electrical engineer in providing such a structure: the modern telecommunication networks. By accommodating so many different voices, they have become a common resource in most of the developed world.

The word 'protocol' is derived from Greek 'first' (προτος) and 'glue' (κολλα), and refers to the first sheet of introduction attached to the medieval parchment rolls used in archives and diplomatic transmissions. The closely related word 'étiquette' is French for 'sticker'. This also conveys the notion of being attached in front of something hopefully more important, as well as of certain ceremonial manners to be observed in official transactions. A derived English word is 'ticket', with all its connotations of permission to do something, of being allowed into, of giving official notice.

*The word 'communication' is derived from Latin 'common' or 'shared' (**communis**). It refers both to something intangible conferred for joint possession - such as news, opinions or communicable diseases - and to general physical connections established for shared transportation.*

*The word 'structure' is derived from Latin 'to build' (**struere**) and refers chiefly to a building of some size or magnificence, with a certain manner of internal organisation or architectural arrangement of different parts.*

Let me conclude the opening protocol by announcing that I have chosen (my way of) Dutch for this inaugural lecture, whereas the printed paper will be in (my way of) English and include some extra technical details. With this arrangement, I hope to bridge the various distances which this special communication process is designed to span.

You may argue, correctly, that the combined use of two different languages provides no guarantee of improved acceptance by the receiver in a communication proces. If so, you are in the excellent company of C.P. Scott, the once famous editor of the (Manchester) Guardian. When confronted with the new invention TV more than fifty years ago, he is reported to have grumbled:

"Television? The word is half Latin and half Greek. No good can come of it".

Today, you may frown similarly upon the new combination 'tele-information techniques'. That is the subject which it pleased Her Majesty to

specify in the Royal warrant appointing me here in Delft. And this combination is two-thirds Greek and one-third Latin, which would evidently not have pleased C.P. Scott. Moreover, the minor Latin part - information - has become too fashionable a word these days to convey any unambiguous meaning. For instance: we have not only information technology, and informatics, and information law, and informatics & law, and information policy, and information strategies, and information theorists, and information managers, and information artists, and many other most respectable information workers - our society is often entitled the information society, and our time the information age! Such grand descriptions belong to the dubious category of truths valid for all societies in all ages, and thus serve to demonstrate that at least historical knowledge is not included in the stock of information cherished by our present society.

The erratic use of the word 'information' confronts scientists and educators in the technological field with an increasing number of theoretical and practical problems, which we are not really competent to solve: How must we structure and exercise our technical disciplines in this new world with so diverse, intense, and chaotic voices - be they professional, personal or political? As academic disciplines, natural science and technology were never focussed on man and his individual or social behaviour. On the contrary, their spectacular successes can be ascribed to our methodological reduction of man to an external position, as either an observer or a manipulator of nature. As Paul Valéry has it: "Nous sommes enfermés à l'extérieur de nous-mêmes."

For a more intrinsic approach to man and his meanings or measures, we traditionally turned elsewhere: to theology or the humanities, to social, legal, economical or political sciences, and to psychology or medicine. Unfortunately, few of these disciplines appear to have risen well to the immense challenge of clarifying the various possible human notions of information. Perhaps as a result, they may now expect punishment by the political and financial powers of our brave new information age.

In these difficult circumstances, I shall explain my subject 'tele-information techniques' in two steps. First, I shall negate the problematic word 'information' altogether, despite the public taste for it, and simply consider the reduced discipline 'teletechniques'. As we shall see, this is concerned with the classical public infrastructure for telecommunication, used for telephony, telex, data transport and broadcasting, in short, for very recognized achievements of electrical engineering. Next, I shall endeavour to add a little 'information' and see whether any good can come of it. That step will expose us not only to the linguistic irony of a C.P. Scott; more significantly, we must face also the many possible human demands for information, of a professional or a personal nature, voiced by the many present and future users of modern telecommunication. And beware - these individual desires take us into the murky areas where economists, lawyers, social scientists or even sexual psychologists may feel at home, but where decent telecommunication engineers fear to tread.

In August 1986, the reverse-charge telephone service of the Dutch PTT (with 06-numbers) suffered dramatic collapses. They happened due to new pornographic audio services being offered for consultation to the general public by inventive businessmen. Possibly spurred by the sensational coverage in the popular press, the number of calls placed by interested Dutch(men) exceeded the maximum programmed capacity in the new computer-controlled telephone exchange in Rotterdam. This caused severe problems for the public mobile telephone system and other 06-services. Apparently, the PTT engineers had not considered the implications of so popular 'information' in their traffic planning.

In accordance with the principle of freedom of information, the PTT did not misuse its statutory power and so avoided censoring the (secret) contents. The government department acted as a company and invoked an emergency clause in its contractual relationship with the offerers to restrict their services to the late evening and night hours, when other traffic is small.

Such desires are not mentioned at all in the classical definition of telecommunication:

'any transmission, emission or reception of signs, signals, writing, images and sounds or intelligence of any nature by wire, radio, optical or other electromagnetic means'.

This technical definition is laid down in the International Telecommunication Convention[1]. It has been accepted by 161 member states of the United Nations, cooperating in UN's oldest specialised agency, ITU. I submit that there is no other discipline at this University whose precise technical definition has been ratified by so many parliaments. Certainly, that would have been quite impossible if the politically laden word 'information' had been part of the international definition. Fortunately, it deals not with information, but with the formal representations thereof: Signals, signs, characters, data and all other symbolic abstractions which may - or may not - be suitable for recognition, reproduction, interpretation or other types of processing, by humans or by automatic machines.

Universities and other technological organisations are not too accustomed these days to such a clear understanding by political authorities of our scientific and educational endeavours. We must be all the more grateful for this excellent definition by international treaty. Succinctly, it pinpoints all academic constituents of the classical discipline teletechniques:

First of all, ITU's definition reminds us that all physical media used to bridge distances in telecommunication are of an electromagnetic nature. Therefore the discipline belongs in the special university departments created in the wake of the formulation of classical electrodynamics by James Clerk Maxwell in 1864-1875, the demonstration of radiowaves by Heinrich Hertz in 1887, the prediction of the electron by Hendrik Antoon Lorentz (1895) and its discovery by Joseph John Thomson two years later.

In short, the home of teletechniques is the Faculty of Electrical and Electronic Engineering.

In Scandinavia, chairs of 'teleteknik(k)' are an established tradition in the electrical engineering departments of their 'Tekniske Höjskole'. These Nordic institutions are siblings of the German 'Technische Hochschule', where there are similar chairs of 'Fernmeldetechnik' and 'Nachrichtentechnik' dedicated to the many scientific problems of practical telecommunication systems. The belief in genuine academic inspiration by the everchanging problems of practical life dates back to the romantic period and Wilhelm von Humboldt. This tradition differs from the American attitude: mass education, deferring confrontation with real systems to the postgraduate level or after the student's acceptance of a post in industry.

My own roots are in the former tradition, at the Technical University of Denmark. Founded in 1829 by the scientist-philosopher Hans Christian Ørsted, who discovered electromagnetism (1820) and produced the first aluminium (1825), my 'Höjskole' established a separate electrical engineering study in 1903. Professor P.O. Pedersen, a civil engineer appointed in 1912 and later to become university director, acquired international fame for his scientific work on radiowave propagation. His inspiration was a close cooperation with Valdemar Poulsen, of the Copenhagen Telephone Company (KTAS), who invented the magnetic voice recorder (1898) and the arc-generator (1903). The latter was the resonant magnetoplasma device used worldwide in long-wave broadcast transmitters, until eventually vacuum tubes could compete with its high output power (upwards of 1 MW).

Like his contemporary in the KTAS engineering group, A.K. Erlang[2], Poulsen never actually moved to the Technical University. Nevertheless, they both influenced electrical engineering profoundly, in Copenhagen and elsewhere.

Perhaps I am rather emphatic about this. But only a few years ago, the Dutch Ministry of Education and Sciences was given to a peculiar belief: With the advent of novel disciplines as computer science and informatics, the vacant telecommunication chair I am accepting today could, in the future, be missed in Electrical Engineering. For was not, the Ministry argued,

my predecessor Professor Bordewijk's discipline*) entitled 'Transmission of Informatics' (sic!) and thus much better 'concentrated' in the modern Faculty of Informatics?

This is a clear example of the risks attached to the fashionable word 'information'. In fact, the argument is the other way round. Due to the amount of data generated and required by the omnipresent computers, new needs for digital telecommunication have arisen. These needs differ, both quantitatively and qualitatively, from anything experienced so far in the century-old history of telephony and telegraphy. Even the much younger analogue broadcasting technology is now subject to radical changes by this development. Evidence of this is the intrusion of superior digital techniques in studio recording, in satellite and radio broadcasts with the quality of compact discs, and as teletext in TV-receivers. All these applications became feasible thanks to the micro-electronics revolution.

As you know, micro-electronics allow very complicated processing of signals to take place very fast, in a very small integrated circuit, at a very minute cost - provided only there is a sufficiently massive demand to finance the chip development in question! The necessity for large volume production of new chips has, in fact, caused some of the most advanced recent developments to take place in consumer-oriented industries, whose strategy will be determined by success or failure on a very competitive mass market[3]. An example is the compact-disc player.

This clear trend away from the exclusive dominance of professional electronics applications, and the increased exposure to the commercial risks in faster moving or consumer-dominated environments, raise significant issues for many professional organisations active in electrical engineering. These problems explain some of the strategic and financial concerns of traditional telecommunication industries and national PTTs - and should therefore also be carefully considered in the training of electrical engineering students.

*) with the real name 'Transmission of Information'.

Micro-electronics and digital signal processing are additional reasons why teletechniques continue to belong in the Faculty of Electrical Engineering. The increased use of bits for representing all sorts of signals as digital symbols has not outdated our excellent definition of telecommunication - even if it sometimes seems hidden behind the more fashionable and shifting vogues of all what can be presented nowadays as information technology. Many young voices can easily shout an old structure down.

It is no use denying that telecommunication as an academic subject has been under some pressure recently. In society, on the other hand, that is not the case: In 1984-85, telecommunication became the area with the highest recruitment demands on the Dutch market for electrical engineers[4]. Moreover, the telecommunication sector is predicted to be the largest single economic sector in the European Community[5] from 1990 onwards. Yet, the academic subject has to be defended, and perhaps not only against a Ministry believing that this subject is just a part of computer science. The following internal critique is possible: 'If we teach electromagnetic theory, coding, stochastic processes, micro-electronics, network and circuit theory for electrical signals and systems - then we have offered all the necessary constituents of teletechniques as defined by you. Really, what more is required in a faculty of electrical engineering offering all that?'

There are two extreme answers to this, the minimal defence and the maximal attack. The minimal defence might be called the **skeleton model**: In this view, a clean skeleton always remains after all the more juicy disciplines of telecommunication have been devoured by energetic vultures from all quarters of the university. That neat structure is seen as the real core of communication, formally describing the interconnections and architecture in which the rest will fit.

The 'skeleton' is of course the reference model for Open Systems Interconnection (OSI), with its various layered protocol and interface specifications[6]. Without such an architecture, modern communications would indeed become a spineless and loose-jointed affair.

The strongest answer, which we might call the **musical model**, takes exception with this modest view of teletechniques: Such a structured approach with its ultimate reliance on formal techniques and program specification becomes so software-oriented that indeed it runs the risk of being seen as pure computer science. The musical model views the skeleton merely as an aid, as the layered score for notation of all parts. Accordingly, the various disciplines of electrical engineering are seen as the instruments or voices necessary to perform a certain piece of communication well. The rôle of the telecommunication engineer is now to tune and balance all these contributions to an optimum orchestral performance, satisfying both composer and audience with an integral approach. In this pleasant perception, the many voices and the one structure complement each other.

The holistic approach to telecommunication derives scientific problems from the system improvements possible by trading off performance between individual black boxes or reference-model layers. It thus thrives best in cooperative environments capable of sufficient mutual understanding of disciplines. Examples of interesting trade offs between disciplines are

- *the use of adaptive control of transmit power or antenna gains to overcome precipitation losses in a satellite network*[7,8,9]
- *the use of reconfigurable multiple-beam antennas to optimise the traffic flow in a multi-user network*[10]
- *the positive influence of channel fading and other disorder situations on traffic congestion in cellular packet networks for mobile users*[11]
- *the potential offered by telematics to trade between capacities for transmission and processing of data, e.g. in networks for remote sensing* [12] *or for distributed graphic terminals.*

A problem with these two extreme positions is that it is objectionable to see your learned colleagues as vultures and yourself as an orchestral conductor. The real situation is probably somewhere in the middle, albeit now more modest in Delft than in Eindhoven and Twente: The techniques of telecommunication are no longer a mandatory subject for all students in our Faculty. That situation is also a considerable difference with the post-war years in Delft, when it would have been inconceivable to evade all lectures given by the professors Bähler, Bast, and Obermann, who all came from the Dutch PTT, and professor Von Weiler, who with his Navy background lectured on microwave techniques, radio systems and electronic navigation.

Undoubtedly, a certain disintegration into the many separate subjects of electrical engineering has occurred since then, with less concern for overall system concepts. I am grateful that this trend may now be reversed by the fusion of our transmission and traffic-control groups, the creation of vacant chairs both in datacommunications and in electronic location and navigation systems, and the support with expert lecturers from the national telecommunication industry and the Dutch PTT. I am also a firm believer in the mutual value of well-defined cooperative projects and complementary research, not only within our Faculty, but also with telecommunication groups at our sister universities and in various industries.

Ladies and Gentlemen,

Arriving at the possible external contacts in society, I have now come closer to the second step in my exposé of tele-information techniques, namely, coming to grips with the word 'information'. It is in this process of looking outside the confines of electrical engineering that one will discover how many voices the world holds. Thanks to an electrical engineer at Bell Laboratories, Claude Shannon[13], we inside have long managed to reduce our necessary business with information or messages to nice little entropy formulas as

$$H = -\frac{T}{\tau} \sum_{j=1}^{n} P_j \log P_j \text{ (bits in T sec)}$$

where τ is the time it takes to transmit one signal or symbol out of a total of n such members, and P_j is the probability of occurrence of number j of these members.

Now, does this look very informative? If not, don't despair! For the great Shannon would himself emphatically remind his colleague electrical engineers that the semantic meaning of the messages thus obtained is irrelevant to our discipline[13]. And that was perhaps a very understandable proposition in 1948 when most services in telecommunication were voice communications between human beings at either end of a telephone network: conversant users have their own personal protocols as given to them by their individual circumstances, moods and language habits, not by the intermediate telecommunication network.

But in the case of modern data communication between computers or other so-called 'intelligent' processors, the mutual recognition of meaning and the necessary agreements on protocol have become valid technical problems. It is no longer feasible to neglect the semantics, the meaning of the message. Thus, a computer cannot compile any program fed to it, if not addressed in a language meaningful to that special application.

In this way, the electrical engineer is now becoming more and more entangled in the various possible applications of computers and data processing. And as we know, these applications are almost unlimited in scope, in meaning and in social impact. The voices in the modern telecommunication networks have acquired many new habits and are asking many new questions - including some very fundamental ones about their own individual meaning and application. And with such semantic or even existential questions, disciples of Shannon are not at ease. In fact, we preferred to think of intelligence as a matter for the user, not our technical business! We really used to think of data, rather than knowledge or information. That yielded us many successes - so far.

Today, it should be realised that the tremendous forces of micro-electronics, programmable processors and digitisation of signals have pushed progress along two widely separated main roads, each passing through its own landscape and thus offering quite different perspectives on people and their customs and habits. One of these main roads is concerned with information systems and individual computer applications, the other with PTT networks and public services. The former belongs to a culture with many voices. The latter is founded on one common structure.

Each of these two cultures has its own history, its own protocols, its own performance norms and its own view of the future use of modern technology. Yet, both cultures are employing the same scientific and electronic basis for their progress; both even believe that their different roads are now converging towards a fusion of computing and telecommunication, in the so-called information society. Nevertheless, this common technology and shared belief mask major differences in direction which have to be understood and addressed - also in our Faculty - if this convergence is to be realised and to bear fruit for the various users.

The national telecommunication authorities have a noble instruction to satisfy the general public's need for telephony, telex and - in a few European countries - cable TV. Each PTT has a national monopoly so that the same uniform services and rates can be provided in both the capital and a remote province, in both Amsterdam and Appelscha. Internationally, this right to equal-access conditions is laid down in the International Telecommunication Convention[1]. All 161 member nations "recognize the right of the public to correspond by means of the international service... The services, the charges and the safeguards shall be the same for all users in each category of correspondence without any priority of preference".

However, this general instruction has not been very conducive to rapid support of the special technological capabilities required to meet highly individual needs in a changing environment. Given the cost of national and international network development, the PTTs have had to think more about making a standard service universally available than about new individual applications of that service. This broad-brush approach has been encouraged by the public control under which telecommunication services must be provided by either regulated 'common carriers' (as in the US) or state-owned civil-service organisations (as in Europe and - until 1 April 1985 - Japan).

In contrast, computer vendors provide specific products on demand to highly diversified markets. In the Western world, they do not have the national government regulating or substantially controlling their commercial activities.
They do not operate with a formal monopoly and can, therefore, more quickly introduce products that meet particular information needs in profitable markets. They need not think about any overall obligation to support a universal service as a public utility in unattractive economical sectors or geographical areas with financial losses. Consequently, their costs of development can be lower than those of the PTT and telecommunication manufacturers. Moreover, the operational life of their products is much shorter. Computer life cycles are typically three to five years. Compare this with the 10 to 30 years it takes a PTT to provide or refurbish any type of public infrastructure - much longer than required to set up a closed computer network for a business on (or between) its premises.

In this way we have now become faced with two very different kinds of professionals - although they are both working with modern information technology. In electronic data processing we expect the fast commercial entrepreneurs, whereas in telecommunication we tend to see the careful and procedural civil servants. It will come as no surprise that the protocols and languages of these two kinds of animals are not exactly similar.

The classical PTT approach strongly influenced the attitude of its suppliers, the manufacturers of public telecommunication equipment. These companies accepted the slow, but reliable purchasing cycles and the performance view of the PTTs. Not surprisingly, they now have difficulties in entering the much faster computer and office-automation markets, which emphasize new capabilities much more than high quality of performance.

On the other hand, the genuine computer companies find it equally difficult to enter the more performance-oriented telecommunication market, whatever their financial strengths.

IBM, for instance, bought its way into that sector by its purchase of Rolm; it seemed unable itself to master private-exchange switching (PABX) technology and performance requirements. Reports have it that the clash of cultures still prevails even now that Rolm is a pure IBM subsidiary. The strategic significance of the PABX is in connecting an internal local-area network (LAN) to public networks. This allows an organisation to reach external clients or information sources.

A computing company may fail to appreciate precisely the different requirements of communication which, despite being based on the same electronic technology, call for other system implementations. These differences are perhaps most dramatic in terms of system reliability and in the response of either culture to this factor. If public phone exchanges required the amount of maintenance and downtime of even modern computer mainframes, the telecommunication network operator would lose his monopoly, or there would be a public inquiry.

In technical standardisation, too, the two cultures are very far apart. It is evident that telecommunication has a longer tradition of interconnection than electronic data processing. A user of any approved terminal in the world's telephone network can communicate with any other of the 530 million subscribers, without having to be aware of any complicated protocol or standards conversion: The PTT networks of

the world, while still based on three different groups of international standards, have common interfaces that take the problems of interconnection off the back of the human user of a terminal.

That is not so in computing. The (user of a) terminal in the computing world must identify which particular protocol its counterpart uses and must be able to 'talk' to it in its own language to ensure meaningful communication. Most types of common standards in data processing were, until recently, entirely ruled out by each manufacturer's individual ways of developing, providing, supporting and connecting different generations of equipment and software.

Standards in the telecommunication world are internationally prepared and recommended in ITU and European consultative committees, widely adopted and stuck to by industrial competitors through several generations of equipments. Within the computing sector big companies even offer equipment that cannot be interfaced with other equipment from the same manufacturer, let alone from competitors.

However, the exigent requirements in the telecommunication sector for maximum reliability, international interfacing and new digital-service integration are now leading to a difficult situation. Technical developments of major new systems are becoming too expensive for any single supplier, not least in the fragmented European national markets. Consequently, an inevitable trend towards joint ventures between large manufacturing companies is now emerging, especially in the fields of public telephone exchanges and public mobile telephone systems (cellular radio networks).

The chief motives for such partnerships have been joint system development (with software costs sometimes approaching 80% of the total development costs), sharing of scarce European expertise in the face of Japanese and US competition (especially in the area of micro-electronics), or penetration of strong national trade barriers.

Examples of such co-operative projects are provided by the recent joint ventures by
- Philips and AT & T (APT)
- CIT-Alcatel, Plessey, Siemens and Italtel
- Ericsson and Thorn-EMI
- ITT and CGE.

Confront this co-operative trend with the computer industry's more aggressive manner of simply taking over weaker competitors and smaller companies with any desired expertise. Recent examples are the acquisitions of
- Sperry by Burroughs
- Rolm by IBM
- Triumph-Adler by Olivetti.
These developments are in accordance with the free-market culture of "killing" competition in the (US-dominated) computer and office-automation industries.

It is interesting to note that where European PTT terminal markets have already become liberalized, large manufacturers may also start to buy themselves into such new competitive telecommunications markets, much as computer industries always did. For instance, the withdrawal in 1981 of the PTT monopoly from mobile telephone terminals for the advanced international cellular radio network serving the Nordic countries (NMT) made the small innovative Scandinavian suppliers attractive to larger foreign manufacturers with less system knowledge.

The early purchase of two Danish companies with a large market share, namely
- AP Radio by Philips of Holland
- Storno by General Electric of the US
illustrates this possible impact of supranational deregulation in the customer equipment sector of European telecommunications.

It is precisely such developments which make some conservative European governments reluctant to relax the grip of the national PTT on the terminal equipment market. 'Their' PTT is seen as a means for securing a strong market position for the national equipment supplier(s) through a restrictive procurement policy. Thus a monopoly intended to guarantee equal access for

national users to a public service, is abused by raising non-tariff trade barriers for competitive foreign suppliers of equipment. The inherent procurement subsidy of the preferred equipment suppliers by such PTTs contravenes not only the EEC treaty[14], but - more seriously - also the basic rationale for the national telecommunications monopoly: minimum uniform pricing of a public utility.

At present many Europeans believe in a strategy guiding the separate courses of the two sectors of information technology closer to each other. It is hoped that the two roads will converge and merge in one mutually stimulating field, often described as the 'telematics' sector.

The various efforts in Europe to close the gulf between the telecommunication and computer cultures include two systematic trends, namely (1) to encourage more voices and (2) to enlarge their common structure. This is done by

1) reshaping of telecommunication monopolies, to allow more dynamic service conditions for wider categories of subscribers and users of modern technology;

2) standardisation of computer technology, in order to enlarge each community of users through maximum equipment interconnectivity, maximum independance from specific vendor designs, and maximum sharing of the increasing non-recurrent development costs of expensive hardware and software.

Can public agencies simultaneously be 'clothed with the power of government' and 'possessed of the initiative and flexibility of private enterprise'? This objective, stated by President Franklin D. Roosevelt in 1933, is again the central issue in the new discussion of telecommunication monopolies in Europe. The international consolidation[6] of the concept of an integrated services digital network (ISDN) and the rapid development of optical-fibre technology have resulted in broader acceptance of the need for heavy extra investments in the PTT infrastructure. These might prove difficult to finance via the government budget. Also, the diverse needs of professional telecommunication users and the many new opportunities offered by micro-electronics suggest a terminal market far too complex for any one dominant organisation, be it a PTT or IBM. In this way, technological developments contribute to a better understanding of the necessity to redefine not only the technical tasks and functions of a national PTT, but also its formal status (now often a government department) and its complex structure (as a regulator, a monopoly providing public utilities, and a competitor with private enterprise).

As for technical standardisation, the Open Systems Interconnection (OSI) reference model, with seven layers of protocols - Fig. 1 - provides some chance of harmony between the telecommunication and computer sectors. But even in their use of this skeleton model there are major differences, for the two cultures approach it with different perspectives. Telecommunication works 'bottom up', from the common transmission and network basis (the 'bearer' services). The data-processing culture views the OSI model top-down, from the side of each specific user application. Accordingly, the providers of communication infrastructures consider mainly layers One to Three; computer users are much more interested in layers Five to Seven.

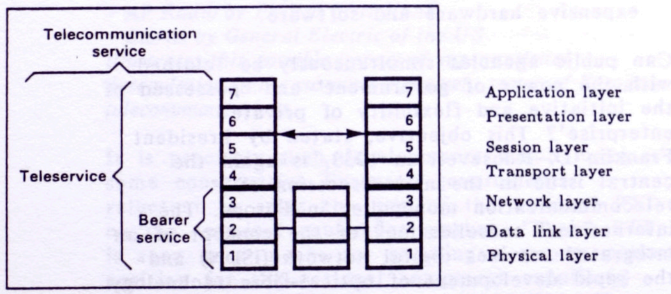

Fig. 1. The OSI model - a skeleton view.

IBM, the computer giant, has been willing to standardise in the field most separated from its own specific capabilities: it supports levels One, Two and Three of the OSI model and, recently, also announced support of levels Four and Five. The last levels it will support, if ever, are Six and Seven, because they are closest to IBM's own corporate strengths in the application field.

Conversely, we see the PTTs give much better support to the bearer services of levels One, Two and Three. As yet they provide but few convincing application services. The X.400 electronic-mail standard may become one.

As long as automation deals only with problems inside the walls of an organisation, as computing used to do, an intra-company or single-vendor approach to standardisation may be acceptable. But as soon as organisations need to reach customers and contacts elsewhere, and thus to deliver or acquire information over open public networks, they need common standards. That is why the OSI framework is becoming very attractive even for IBM. IBM users now need the European PTTs, and so IBM has joined those advocating the joint international responsibilities of the national PTTs in Europe.

How then can these two different economic sectors co-habitate in the modern electronic technology world? First, they must become more aware of each other. They should recognize and exploit the cultural differences and regulatory separation, instead of trying to mask them. Secondly, they should realise that the most permanent success in the provision of services comes about when the integrity of a common telecommunication infrastructure is preserved. This ensures the strongest network growth and the widest user connectivity. The worst policy would be to allow fragmentation of the common infrastructure and, at the same time, to restrict access of different voices to this infrastructure. The best policy is to improve the common infrastructure of public telecommunication and, at the same time, to allow the most liberal market policy of providing new information services and type-approved terminal equipment in free competition.

This trend is indeed emerging in Europe. It has been adopted - in principle - by the Netherlands Government and Parliament, following the recommendations of the Steenbergen Committee[15] in which I served. Clearly, this Dutch solution was not developed without consideration of the most promising options in other European countries. The UK, Denmark and Finland inspired the licensing solution to the legal problem of ensuring a flexible monopoly. The unprecedented high development pace of the Nordic Mobile Telephone system (NMT), combining a single international public infrastructure held by four national PTTs with commercially provided, type-approved customer terminals, demonstrated a convincing way of satisfying different voices rapidly - without fragmenting their community of interest (as happens in the many competing local cellular radio networks in the US).

The Swiss system of licensed competition for installation of PTT terminals; the wide Danish range of attractive telephone designs available to the ordinary residential subscriber at little or no extra cost; the profit centres in the Swedish Post Office - all are proofs of the feasibility of showing the initiative and flexibility of private enterprise in a European public environment.

The publication and discussion of long-term investment plans for PTT network development in West Germany, and the EEC pre-competitive research programme in optical telecommunications (RACE) show the proper involvement of an executive power in industrial policy: in these ways, development of the public infrastructure is given a higher priority than private industries can do on their own.

Using available X.25 data communication infrastructures in Europe, the academic and research communities in Europe are developing joint services such as file transfer (FTAM) and electronic mail (X.400), with support from national PTTs. Among such projects are JANET in the UK, DFN in the Federal Republic of Germany, NORDUNET in Scandinavia and REUNIR in France. The reluctant support from the Dutch authorities for the SURF-project is an indication of a failing understanding of the need for one structure to support the many voices at our 14 universities and many research institutes.

Ladies and Gentlemen,

An absolute prerequisite for placing the various applications of modern information systems in the full context of teletechniques is better education. This is urgent, both in quantitative and qualitative terms. The output of graduates (with a first-phase engineering diploma, at the Master's level) in telecommunication directions must be increased significantly to match present and future demands of the Dutch labour market. When the PTT status is changed into a limited-liability corporation (NV) rather than a civil-service organisation in January 1989, the competition about the scarce engineers with a telecommunication background can be expected to increase further, due to the improved salary conditions which may then be offered by PTT as a private employer of very large proportions. (The telecommunications staff of PTT is now about 37,000 civil servants, with many vacancies at the academic levels).

Postgraduate (second-phase) students in telecommunication are, already now, few and far between. This is partly due to a peculiar Dutch tendency to regard a doctor's degree in system engineering as either too difficult or irrelevant to the customary engineering career: life-long service within a single large organisation, typically starting in its research laboratories in a deeply specialised field and not in integral system disciplines. This dominant trend is absent in countries with competitive smaller 'high-tech' companies or more technical consultancies, and with less rigid pension schemes. Recently, the Dutch Ministry of Education and Sciences has seen fit to complicate university recruitment of young scientific assistants (aio's) further, by introducing general salary cuts of some 40% for this kind of - temporary - staff.

Young telecommunication graduates can negotiate starting salaries above f 4000 per month in the private sector here and abroad, excluding any taxable fringe benefits (car schemes, etc.). Until September 1986, a Dutch university could offer its young postgraduate students f 2577 per month, irrespective of their Ph.D. subject, talent and *involvement and of the prevailing conditions on the labour market. At present, their starting salary is set at f 1758 per month; nevertheless, the service period is still limited to a maximum of 4 years.*

Given this inflexible approach, I expect that most full-time postgraduate students must be attracted either from non-EEC countries, or by additional (guarantees of) emoluments paid by interested large companies. As a foreigner, it is not for me to discuss whether this will be the best way of serving the public interest and smaller enterprises in the Netherlands. But as a telecommunication engineer, I have observed that Dutch civil-service regulations now make it virtually impossible to insist on the highest educational standards in rapidly changing segments of the national public sector.

This was one of the major reasons for the Steenbergen Committee[15] *not to recommend a civil-service or other public status for the future PTT, but a corporate structure. It is noteworthy that all major parties in Parliament have endorsed this far-reaching recommendation. Do they realise that the universities of technology are under the same innovative pressure as the PTT and have the same inflexible structure?*

Traditionally, the emphasis of electrical engineering research and development has been on **process innovation**, that is, seeking still **better performance** of existing applications by introducing new technologies. The gradual implementation of digital transmission and switching techniques, optical cabling and satellite telephone trunks are examples of such performance improvements in telecommunications. The users do not observe them, except by the ever lower cost and ever higher quality of services.

The more fundamental technological changes to society and economic life reach far beyond this mere improvement of existing processes; such changes come about by offering **new capabilities** to new classes of users or different markets. Thus, the most radical influence of satellite technology was not the cheaper international telephone connections. Satellites have also demonstrated a unique ability to reach entirely

new users: by instant TV programme delivery from all corners of the globe during Olympic Games, regional wars, etc.; by extending classical public telecommunication services to remote regions in the less favoured regions of the world or to mobile users at sea and in the air; by not respecting national borders in direct broadcasting; and by allowing distributed computer processing worldwide, for instance in electronic-mail or remote-sensing networks.

Such examples indicate that we cannot limit ourselves to classical process innovation in our electrical engineering education - we should expose our students more to the possibilities and problems of **product** and **service innovation**. This is particularly important in my discipline, because it will be most exposed to the ongoing transformation from telecommunication to tele-information services[16,17] and new electronic media[18].

Generally, tele-information services will add extra value above the pure worth of fast long-distance transport. For this reason, they are often called 'enhanced' or 'value-added' services, as distinct from traditional 'basic' or 'common carrier' public service. Most of these designations descended upon Europe from the United States and require a current understanding of the complicated US anti-trust regulations.

A more international service distinction, based on the OSI reference model and ITU work, is that between 'teleservices' and 'bearer services' (Fig. 1). The latter are likely to be considered a natural (PTT) monopoly in most European countries, in order to safeguard the public equal-access conditions laid down in the International Telecommuniation Treaty (quoted on page 16). On the other hand, noting that the EEC Treaty forbids abuse of a dominant position to deny consumers new products or services[14]*, it is probable that the European Commission and, if necessary, the European Court of Justice will play active rôles in deciding whether new teleservices can be claimed by a national monopoly or offered freely in (international) competition.*

There are many indications that the European Commission will promote new tele-information services and products much more actively in the future. It will do so not only by stimulating joint

R & D programmes, but also by using its executive power to intervene if competition in telecommunication is hindered in a counterproductive manner. This, in turn, will stimulate leading European PTTs and telecommunication industries to take far more commercial initiatives than in the past, and will thus increase their demand for a new type of engineering staff trained to see the market opportunities in modern telecommunication. Conversely, other organisations will require managers[19] who can make more informed technical decisions about the various commercial or non-profit activities which can be based on telecommunication, either as a user or as a provider of tele-information services.

Ladies and Gentlemen,

Even if only some of my predictions will prove correct, we are facing a more exigent educational task in telecommunication than hitherto. It is for this reason that Delft University will, from January 1987 onwards, offer a new postgraduate course for experienced telecommunication engineers. Unlike the full-time postgraduate studies, this new course must be followed part-time by engineers employed elsewhere, and aims at service and product innovation - not process innovation. This means that the emphasis will be on providing a wider grasp of the functional and operational aspects of new tele-information systems and network services - not on the detailed design or development of improved components or special subsystems. The purpose is to improve the academic background for a more rational, or at least conscious, approach to the challenges and opportunities of modern telecommunication technology. This will require more interdisciplinary work than electrical engineering students now expect. Thus, lectures by lawyers, consultants, system planners, marketing experts and policy makers will be added to the many familiar voices of our good old faculty structure.

I hope that the demand for this new type of professional competence will prove sufficient to support our initiative in the years to come. There is a promising interest, from the Netherlands and from abroad. We need this interest, for it is the market which must pay entirely for this postgraduate course! Thus, it will be an expensive study - except for the Ministry of Education and Sciences, which subsidises only the preparations.

In addition to a belief in the permanent need for an engineering university to graft its academic activities onto the most significant developments in society, I have another personal reason to have worked for the introduction of this kind of postgraduate course in the Netherlands. During the last three to four years, I have noted an exhausting - lately almost mortal - need for support by the few Dutch telecommunication professors in all sorts of multidisciplinary committees, steering groups, councils, boards and advisory policy groups. To me, that need suggests a requirement for a broader education of more people to understand the tremendous influence of telecommunications on our future world. It also seems to suggest that we must try to contribute at least some of the discussion of so important questions a bit closer to our own University.

If our new postgraduate course succeeds, my colleagues and I can, with a much better conscience, refuse the various honourable invitations to sit in the well-nigh infinite number of fora who will be considering the impact of tele-information services and modern telecommunication in the future. At present, such refusals are still taken as lack of a serious commitment to society, rather than simply a serious lack of time.

Ultimately, it is for society itself to decide on what information is free for all, and what information is personal and confidential. When broadcast, telephone and new tele-information services are all provided in one integrated network, by one structure, more conflicts of interest between the rights to information and to privacy or secrecy can occur[20]. You may experience such conflicts shortly, when the Zegveld Committee reports on the future of Dutch cable-TV networks, and when the Franken Committee reports on the future of the Dutch penal code concerning public protection against computer and communication crime.

Ladies and Gentlemen,

At the end of my lecture I should like to express my gratitude to H.M. the Queen for my appointment and for the liberal Dutch tradition of accepting foreign labour in national academic institutions.

Mijne heren leden van het College van Bestuur.
I thank you for the confidence placed in me by your nomination of me to the Crown. I shall do my best to meet your trust.

Dames en heren hoogleraren en medewerkers van de Faculteit der Elektrotechniek, in het bijzonder van de nieuwe vakgroep Telecommunicatie- en Verkeersbegeleidingssystemen.
You have received me exceedingly well, long before I started working here in May this year. I hope that we shall enjoy the many great challenges and professional opportunities of the future together. I am especially looking forward to reaping with you the fruits of creating one Telecommunication and Traffic-Control Systems Group, living higher and closer together, and thus listening more to each other's voices than in the previous structure.

Dames en heren hoogleraren en medewerkers van de Faculteit der Elektrotechniek van de TU Eindhoven, in het bijzonder van de vakgroep Telecommunicatie.
Leaving the dedicated and prolific radio-communications team and the transparent management style at Eindhoven University was no easy choice. I hope not to have forfeited the pleasure of future cooperation with you, and wish you much success.

Dames en heren directieleden en medewerkers van het Staatsbedrijf der PTT, in het bijzonder het Dr. Neherlaboratorium.
Except for a spell as scientific advisor at your research laboratories, I have never been employed by the Dutch PTT (or any other PTT). This is a break with a valuable tradition of more than 55 years for the chair I am accepting today. I hope that you are, nevertheless, convinced that I have tried to serve you in other ways and will continue this effort.

Hooggeleerde Bordewijk.
You were the first in the Netherlands to draw attention to the potential of new tele-information services. I am honoured by being your successor, and by having worked with you on creating public awareness of the importance of modern telecommunication structures, amid more commonplace voices about informatics and computers.

Zeergeleerde Steenbergen.
More than anybody else, you showed me the importance of methodical charting the strengths and weaknesses of complex human networks, before political, legal or technical design can be brought to bear. The work under your chairmanship rebuilt my confidence in Dutch social innovation.

Hoogedelgestrenge Tjeenk Willink.
Your careful analyses[21] and our many discussions developed my understanding of the peculiar Dutch civil-service conditions, in which both PTT telecommunication staff and university teachers attempt to work on innovation for the common good. You taught me that the first problem is the common political inability to define 'good', not innovation.

Hooggeleerde Bach Andersen, käre Jörgen.
From you, I learned the joy of formulating and solving complex boundary-value problems, and the need to think about practical approximations. I have long since left eletromagnetics, but your friendship and professional attitude is still with me.

Hooggeleerde Stette, käre Gunnar.
You taught me the feel and responsibilities of system engineering. The necessity to take an informed broad view, and subsequently to take decisions, was demonstrated by you on our precious projects and precious travels together.

Käre mor og far.
Denmark sometimes seems far away, but never your professional examples and commitment. What better youth for a telecommunication engineer than mine, between so many poetic voices[22] and one structured approach[23] to providing transport services in organisations!

Dames en heren studenten.
You are the real reason why I am now again accepting a university appointment: The greatest challenge is to work with young interested people trying to understand more - and taking less for granted - than experienced holders of fixed positions. One generally profits from being mobile - first between subjects, later between positions - and listen to the many voices that any good structure supports, before making one's own informed choice.

My wife, who is my reason for choosing for the Netherlands, teases me that her university years in Leiden were spent in the good company of Delft students. However, she also tells me that most electrical-engineering students in those days were introverts ('knorren') and nearly invisible in social life. If this is still so, it bodes ill for the information society! Lest you think that all valuable information is of a purely electrical nature or can be acquired as data inside our faculty microprocessors, let me close this lecture with T.S. Eliot's query to us all:

WHERE IS THE WISDOM WE HAVE LOST IN KNOWLEDGE?
WHERE IS THE KNOWLEDGE WE HAVE LOST IN INFORMATION?

Thank you for your attention.

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