ATR

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Special Issue —
INTERNATIONAL
DATA COMMUNICATIONS
STANDARDS SEMINAR
MELBOURNE, MARCH 1982

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Foreword: In Praise of Special Issues

This is the third occasion in the sixteen year history of ATR that the Board of Editors has recommended that a Special Issue be published, as a bonus to subscribers. In each case, the Special Issue has published a collection of papers, highly relevant to Australian telecommunication research, and previously delivered at an important conference held in Australia, drawing many impressive speakers from both Australia and overseas.

The first Special Issue (Volume 7, No. 3) published the papers delivered at the "Whither Communications?" symposium on the occasion of the Golden Jubilee (1973) of the Telecom Australia (then APO) Research Laboratories. Amongst the invited speakers were heads of telecommunications research laboratories from around the world, and their ability to accurately predict the technological future is staggering to the reader of their papers, nine years later: all the current 'futuristic' innovations in telecommunications technology and services - telematic services, integrated services digital networks, fibre optics, computer aided network management - were correctly identified by those invited speakers in 1973. Their papers are still worth reading.

The second Special Issue (Volume 11, No. 1) was devoted to the Australian contributions to the Eighth International Teletraffic Congress (ITC-8) held in Melbourne in November 1976 - the only time this Congress has been held in the Southern Hemisphere. The staging of the ITC-8 can be seen with hindsight to have been the zenith of the Golden Age of teletraffic research in this country, for the Teletraffic Congress stimulated the writing of an impressive collection of high quality papers from within Telecom Australia - HQ and States - and from Australian universities and industry. Six years later, many of these papers are still valuable references.

The third Special Issue of ATR publishes the invited papers delivered by world experts on data communications at the International Data Communications Standards Seminar, held in Melbourne in March 1982. The Seminar's technical programme was organised by Australian telecommunications researchers, and the key speakers were generally CCITT Chairmen and Special Rapporteurs in certain CCITT standards-developing Working Parties which held meetings in Melbourne in the weeks immediately preceding the Seminar. The Seminar's Opening Speech by Telecom Chairman Mr Bob Brack explains Telecom's general motivation in hosting the Seminar; I have also asked the principal organiser of the Seminar, Dr Fred Symons, to contribute a short additional paper outlining the organisation of the Seminar and his own views on the benefits to Australian telecommunications organisations of continued participation by their staff in the development of international standards.

I believe that, as with the two earlier Special Issues, many of the papers published in this third Special Issue of ATR will be seen to be of considerable reference value for many years to come. Viva the Special Issue!

PETER GERRAND
Editor

Acknowledgements

The assistance of Michael Hunter and Chris O'Neill together with several other colleagues from Telecom Australia's Research Laboratories in the proof-reading and production of this Special Issue has been greatly appreciated.

Opening Speech

R.W. BRACK
Chairman, Telecom Australia

Mr Chairman,

Ladies and Gentlemen,

I am very pleased to extend to you a warm welcome to this seminar on international data communication standards.

Members of Telecom Australia's staff have put considerable effort into planning and organising this seminar. By the enthusiastic response to our initial advertising of the seminar, which is evident from the attendance here today, it is clear that this technical seminar is regarded by the Australian telecommunications community as being both timely and valuable.

I would like to tell you how and why this seminar came about.

Telecom Australia is an active participant in the development of international standards, particularly those developed through the workings of the relevant expert technical committees of:

- the International Telecommunications Union (the ITU);
- the International Electrotechnical Commission (the IEC); and
- the International Organisation for Standardisation (the ISO).

In particular, the technical committees of the ITU are grouped into two families of study groups:

- the CCIR, (International Radio Consultative Committee) which is concerned with radio matters; and

- the CCITT, (International Telegraph and Telephone Consultative Committee) which is concerned with telephony, telegraphy, data communication networks, and how to inter-connect any of the host of new services described by the CCITT as telematic services.

"Telematic" is a descriptive term, coined by the French, to describe new services arising from the integration of telecommunication networks and automatic computer systems.

You will hear the initials CCITT and ISO mentioned regularly during the next day and a half.

Over the past three weeks, Telecom has hosted meetings in Melbourne of CCITT Study Group VII's Working Parties 3 and 5.

These Working Parties are responsible for developing proposals for technical standards relating to networking and inter-networking for public data communications networks. The delegates who attend these meetings normally consist of technical experts, recognised within their own organisations as being at the forefront of the relevant technology, as well as being capable representatives of their own organisational and national interests. Furthermore, since these international standards committees traditionally reach their decisions by consensus, the delegates are normally required to be skilled communicators, in order that their technical arguments may have a reasonable chance of impact on their colleagues, and through their regular attendance at these meetings, these delegates develop a world-view of the state of the art of their particular areas of technology which is second to none.

Given the calibre and experience of the delegates attending the CCITT Working Party meetings in Melbourne this month, it would have been remiss of us not to provide an opportunity for Australian data communications professionals to keep abreast of the latest developments in data communications standards.

We are very grateful that leading technical experts amongst the CCITT Study Group VII Working Parties, including the Study Group Chairman (Mr MacDonald) and the CCITT Counsellor (Mr Okabe), have agreed to stay in Melbourne for several extra days in order to take part as speakers and panellists in this seminar. Knowing the high pressure of the demands placed on these delegates as key individuals in their own organisations, it says a great deal for their dedication to the development and promulgation of data communication standards, and for the priority placed on standards development by their own organisations, that they have agreed, and have been able, to participate in this seminar.

Standards are becoming increasingly important in telecommunications; increasingly important to manufacturers, telecommunication administrations and users alike.

The developments costs for building complex communications equipment are sufficiently high to make manufacturers vitally interested in monitoring the evolution of relevant standards, and wary of moving too far in advance of developing standards, in case their equipment products may require major modification to make them compatible with other suppliers' equipment.

For example, the "Electronic Office" concept cannot viably exist on any national or international scale without suitable standards: standards for interconnection of equipment, standards for formatting of data, and standards for the methods of accessing standard facilities and services.

From the point of view of telecommunication administrations like Telecom Australia, standards are absolutely vital to enable effective nationwide and worldwide data communications. As the national network provider, we need standards:

. to guarantee compatibility between your terminal equipment and our network;

. to guarantee compatibility between your terminals and those other terminals connected to our network with which you wish to communicate;

. to guarantee quality of service, that is, to guarantee you an end-to-end service with performance better than a stated minimum error rate;

. to guarantee you a uniform geographic coverage of services - so that your Hobart office can attach the same terminal equipment as your Perth office;

We also need standards to guarantee fair opportunities for manufacturers and suppliers:

. to give them access to the whole Australian network, and hence larger scale economies, rather than require specialised equipment development for different zones;

. and to provide stability in the technical specifications to which the manufacturers must commit their considerable development resources.

From the third point of view, that of the users, standards are needed to permit confidence:

. that the terminal equipment they purchase or rent will be able to interwork safely with the network;

. that their terminal equipment will be able to interwork satisfactorily with other, similar equipment attached to the network;

. that their communications will not become garbled, nor will they lose vital information, except under conditions engineered to be of very low probability.

In short, the timely development of sensible telecommunications standards is in the interests of the total community.

I heard a story by an old-timer about the difficulties in making telephone calls between Australia and North America thirty years ago, when most of the links in the communication chain had to be made by manual operators. In those days a call from Melbourne to, say, an outback town in Saskatchewan, might have required the assistance of five or six operators, one after the other, in connecting together the appropriate telephone lines.

On one such occasion it took more than thirty minutes to set up a telephone call between our Melbourne man and a cousin of his in Northern Canada. He had only just said 'hello' to his cousin when a particularly helpful operator, in Vancouver, perhaps the No. 3 operator in the chain, cut in to ask sweetly, "Are you through yet?" When our Melbourne man happily replied "Yes, thank you", she went and disconnected him!! It was then that he realised that the expression "Are you through?" can mean at least two different things, even amongst fluent English speakers.

We have come a long way on the standardisation of communication protocols since then, I hope.

It only remains for me to wish the speakers and delegates an informative and successful seminar, and to declare my hope that the increased knowledge and awareness gained from this seminar of the state of development of the new international standards for data communications will be of benefit to us all.

BIOGRAPHY

Robert William Brack, A.O., was appointed as Chairman of Telecom Australia commencing on 16 November 1981 for a period of five years. Mr Brack is Vice-Chairman of the Australian National Airlines Commission (T.A.A.).

Mr Brack was the former Managing Director of Australian Consolidated Industries Limited. He has had many years experience in government and private enterprise, including the Australian High Commission in London and the Australian Embassy in Washington.

Organisation of the International Data Communications Standards Seminar

F.J.W. SYMONS
Chairman of the Organising Committee

As part of this Special Issue of ATR, I welcome the opportunity to make a few remarks about the organisation of the IDCS Seminar, the related meetings of CCITT Study Group VII Working Parties VII/3 and VII/5, and the relevance of this type of CCITT Meeting and Seminar to Australian telecommunications people.

Those of us deeply involved in the organisation of the Seminar were extremely pleased that it was so well attended, that it ran smoothly during the two days, and that the talks and panel sessions proved to be of obvious interest and benefit to the delegates. The success of the Seminar was especially pleasing as it was organised with a short lead time, most of the organisers had never tackled a similar task before, and at the time of commitment to proceed there was a wide range of opinion on the level of interest which would be shown by the Australian data community. The complimentary remarks made by many of the delegates and by several of the technical journals and newspapers about the content of the Seminar, the organisation of the Seminar and Telecom's capabilities in the data communications field provided deep satisfaction for the group of dedicated people who worked long hours well beyond the call of duty over an extended period.

The Seminar was organised by a committee composed of officers of the Telecom Research Laboratories and the International Branch of the Secretariat, with assistance from the Data Division of Commercial Services Department and the General Accounting Branch. The tasks involved in organising the Seminar were made more critical and demanding as many of the people from the Research Laboratories and the International Branch were also deeply involved in organising and participating in the CCITT Working Party Meetings for the three weeks immediately preceding the Seminar. I am sure that I am representing all the delegates of the Seminar in offering my deepest thanks to all those people on whose dedication the success of the Seminar depended.

In his Opening Speech at the Seminar, Telecom's Chairman Mr R.W. Brack described the relevance and value to all sectors of the Australian data community of timely, definitive and flexible standards for data communication, especially those concerned with public data communication networks. I would like to take up the related theme of the benefits to be obtained from continued deep participation, especially by Telecom staff, in the further development of international standards for telecommunication networks. It has been the recognition of these benefits to Australia and to Telecom, and the creation of opportunities for a large number of Australians to participate in meetings of CCITT, that has prompted a small group of people in the Telecom Research Laboratories to take the initiative several times since 1978 in proposing the holding in Australia of carefully selected Working Party meetings of CCITT Study Groups.

Over the last twenty-five years several Australians have made significant contributions to the organisation and technical achievements of CCITT and CCIR, and Telecom has made extensive use of international standards. With the currently imposed limitations on attendance by Telecom staff at overseas meetings of international standards bodies such as CCITT, there are limited opportunities for Telecom staff to participate deeply in the important work of developing standards for the Australian telecommunication networks. In my opinion, there is a strong need for an increased level of participation, and Telecom, Australian industry and the Australian community will suffer substantial real losses if the prevailing limited level of participation is continued. However, rather than spelling out these losses I will concentrate on commenting on some of the benefits which would be obtained by a much increased level of Telecom and other Australian participation.

In the current situation of worldwide automatic telecommunication networks being developed and extended for telephony, telex and data services in the context of rapidly changing technology and cost structures, Telecom is conducting an essentially technical business which requires a clear understanding of the technological future. In addition to the application of enlightened modern business practices, Telecom's mastery of new technology and techniques will be critical to its success as a business and to the quality of service it provides. Only with broad and deep competence in the understanding and handling of new technology will Telecom be able to assess total situations quickly, make accurate predictions, take sound decisions and provide the necessary high level of leadership to Australian industry well in advance so that industry can deliver new systems at the required times for the optimum development of the network and the provision of improved or new services.

Over the last few years the nature of many of the telecommunications standards setting activities has changed considerably. The development and definition of standards is now very close to basic system and network design and to research work. Standards are now being set ahead of widespread application and new technical ground is being broken in the international Working Parties. High quality standards can only be produced effectively by a group of people with experience in the latest techniques and technologies and a clear vision of the technical future. The inclusion in the standards of any special requirements of the Australian networks and their customers can only be assured if experienced Telecom staff participate in the meetings.

Continuous deeper involvement with the Working Parties and Study Groups of standards-making bodies like CCITT would enable Telecom to build up better informed first hand knowledge and awareness of the worldwide state of the art in relevant areas. This improved base of experience and perspective would enable Telecom to identify more clearly the implications of key decisions concerning the technical and economic operation of Telecom's networks. Formal and informal involvement in these meetings also brings with it much earlier indications of likely developments and changes throughout the world - and in the rapid rate of change which will occur for the foreseeable future, even gains of six to twelve months are invaluable.

Against the background of the comments made above, it is important to make the point that it has been proved, given the opportunities, that Australians in general and Telecom staff in particular, are equal in calibre to those of any of the leading countries. As an example, at the CCITT Working Party meetings preceding the IDCS Seminar, several of the Telecom staff, following intensive preparation, made very significant contributions in selected areas, especially concerning Formal System Description Techniques and the development of the definition of the Transport Service and Protocols. In addition, six officers of the Switching and Signalling Branch delivered four well attended and well received evening tutorials to the CCITT delegates, on topics where they had something to offer which was significant on the world scene. Several of the overseas delegates made complimentary remarks about the quality and quantity of the Telecom contributions to the CCITT meetings.

Opportunities to hold frequent discussions, as an equal, with experienced respected overseas people increases enormously the confidence of the Australian people in their own abilities and provides a spur for them to increase their capability to proceed with further fruitful developments. If these opportunities were extended significantly, this increased confidence and capability would spread rapidly through the Telecom organisation, increasing the overall level of expertise and judgement, and would enable better decisions to be taken earlier with less effort, resulting in a large increase in productivity, overall effectiveness and satisfaction to all concerned.

I hope that the above comments throw some light on why a relatively small group of people were prepared to make significant personal sacrifices of time and energy to enable CCITT Meetings and the IDCS Seminar to be held in Australia.

BIOGRAPHY

Dr F.J.W. Symons. After graduating from the University of Adelaide with First Class Honours in Electrical Engineering in 1959, Fred Symons worked as an Engineer in the Telecom Australia Planning Section, South Australia. In January 1961 he left for England to undertake a GEC Overseas Fellowship for two years in the Telecommunications Division, Coventry and the Research Laboratories, London. His time in England was extended for one year to undertake the postgraduate course in Communications and Electronics at the Imperial College, London, concentrating on statistical communication theory.

From 1964 to 1975 he worked in the Telecom Research Laboratories on a wide range of network and system studies, especially concerning digital systems and networks, and remote control.

In the middle of 1975 he was awarded a Telecom Australia Postgraduate Scholarship and spent three years at the University of Essex, England conducting research into the modelling and analysis of communication protocols using Numerical Petri Nets, for which study he was awarded the degree of Doctor of Philosophy. In May 1979 he returned to the Research Laboratories where he is currently Assistant Director, Head of the Switching and Signalling Branch.

CCITT Data Transmission Studies and Results

V.C. MacDONALD
Chairman, CCITT Study Group VII

1. INTRODUCTION

Following the VIIth Plenary Assembly of CCITT held in Geneva, November 10-21, 1980, a new issue of CCITT Recommendations is appearing in ten volumes, each embracing a wide sector of telecommunications. Yellow Book Volume VIII covering Data Communications is bound and sold in three separate booklets, as follows:

FASCICLE VIII.1

Data communications over the telephone network. V Series. Recommendations (Study Group XVII).

FASCICLE VIII.2

Classes of data communications networks services and facilities, data terminal interfaces to public data networks. Recommendations X.1-X.29 (Study Group VII).

FASCICLE VIII.3

Data communications networks, transmission, signalling and switching, network routing and numbering, maintenance, administrative arrangements. Recommendations X.40-X.180 (Study Group VII).

For service and network planning, related CCITT Recommendations include:

> Tariff Principles (Volume II, SG II)
> Digital Networks (Volume III, SG XVIII)
> Signalling System No. 7 and SDL (Volume VI SG XI)
> CCITT Recommended Telematic services and Terminals
> (Volume II.4, SG I) (Volume VII.2, SG VIII)

2. DATA TRANSMISSION ON THE TELEPHONE NETWORK.

Is data transmission essentially different from telegraph transmission? The answer is yes and no: data transmission makes use of pulse transmission techniques as does telegraphy, but generally at higher speeds and with greater emphasis on error control than in conventional telegraphy (Ref. 1). Hence, while data transmission can be compatible with telegraphy, the objectives are however different. In telegraphy and telematics the final aim is to produce a text which can be read. In data transmission the aim is involved with electronic processing of information. But data transmission is also capable of digital telegraph telematics or digital facsimile message transmission.

The essential characteristics of data transmission can be summed up in three words: speed, reliability, and flexibility.

The signalling rates available on the telephone network for data transmission cover a very wide range. Unlike CCITT defined services such as Telex or Telematics data customers do not require every user to have the same type of terminal. They use data transmission in many different ways, with many different single and multiple user-owned data equipments.

The wide range of data signalling rates offered on the telephone network goes up to kilobits per second. 300-1200 bauds soon became a common range for data calls set up on public telephone networks. The modulation rate in "bauds" used at these lower speeds, is the reciprocal of pulse duration. When transmission is effected by a serial stream of pulses, the transfer rate of information "bits" is the same as the baud rate. This is conventional two-condition modulation. Other modulations are needed at higher bit rates.

Since 1969, 2400 bits per second four-condition modulation (four phase) using dibit encoding has been the subject of CCITT recommendations. In 1972, 4800 bits per second was introduced using eight-condition modulation with an adjustable equalizer on the analogue/digital tribit encoding data circuit equipment (modem). In 1976, 9600 bits per second capability was introduced, the scrambled data stream being sent in "quadbits", the additional encoding using amplitude as well as phase of the transmitted carrier.

3. PLANNING FOR CCITT RECOMMENDATIONS IN DATA COMMUNICATIONS.

In 1967, at the same time as administrations and RPOA's were increasing the capabilities of circuit terminating equipment (modems) for data transmission on telephone circuits the following concerns were noted in CCITT studies:

:: the rapid expansion of data-type services all over the world;

:: the indicated need for data-type services at high data signalling rates up to 50 kilobits/s and above;

:: the indicated need for very fast set-up time in a switched network for data transmission;

:: the indicated need for flexibility in the selection of data signalling rates for particular services;

:: the indicated need for auxiliary controls on a data connection;

:: the indicated need for interconnection of facilities which carry data either in a switched network or a leased service (more recently, interconnection with Local Area Networks has been indicated);

:: the indicated need for transmission at low error rates;

:: the indicated need for transparency in the transmission medium with respect to the format and codes of the data;

:: the possibility of a switched network using "store-and-forward" principles;

:: the possibility of an integrated network using time-division principles and computer technology for transmission, switching and control.

The IVth Plenary Assembly at Mar del Plata, October 1968 therefore set a new Question in three parts. (Ref. 2).

:: the use of telegraph and telephone-type switched networks for combined operation with data services;

:: the characteristics of a separate switched network for data-type services;

:: the use for data of a future network for general telecommunication services (data, telephone, telegraph, etc.) employing time-division techniques with an integrated basis for transmission, switching, and control.

4. PROGRESS OF STUDIES AND EARLY IMPLEMENTATIONS.

Since Mar del Plata, over a thousand contributions to these questions and their successors as set in 1972, 1976 and 1980 have been studied in CCITT. As well as from Administrations, RPOA's and other CCITT Member Organizations, some came from the Technical Committee on Computers Information Processing and Office Machines of the International Standards Association (ISO/TC 97) and some from the International Federation of Data Processing (IFIP) as well from other international organizations such as WMO and ICAO.

Technical papers began to appear in professional conferences (Ref. 3) showing that the three sectors of the classic 1969 problem were receiving very serious study. System concepts, market studies, and planning for implementation were active in most industrialized countries.

The main difficulty in the argumentation in favour of a data network was a reliable estimate of the number of subscribers, the nature of their requirements, and the traffic volume for which any specialized data network was to be dimensioned.

In the Federal Republic of Germany (Ref. 4) it was planned to replace all exchanges of the telex network between 1973 and 1977, and then to operate a great number of concentrators of different types (for 40 to 1,000 subscriber stations) by about 30 controlling electronic data switching centres (EDS). The use of concentrators was to allow all applications of potential data subscribers in the Federal Republic of Germany to be satisfied from 1975 onward.

It was considered that the new facilities required for improved data traffic could only be incorporated into the existing telephone network over a very long period of time and that the indispensable facilities for the data traffic (such as short setting-up time, low error rate, high grade of service, etc.) would be too high a burden on any combined network for telephone and data transmission. It was assumed that the number of data subscribers would be relatively small as against that of the telephone subscribers.

This conclusion, namely that the required facilities can only be provided by a special data network, applies as long as the telephone network operates on the basis of analogue transmission and switching techniques.

In the United Kingdom (Ref. 5) a study of the characteristics of the traffic to be carried resulted in proposals which included two modes of network operation:

:: "Circuit" switching

A method of call establishment where the caller is allocated a discrete path to the called party as typified by the telex and telephone services. It is particularly suitable for data connections involving continuous high information rate, such as bulk data transfer from computer to computer. It provides the user with a constant transmission delay for the duration of the call.

:: "Packet" switching

A method of data transfer analogous to the store and forward technique used for telegraph switching. Blocks of data are routed through the networks. The "packets" are of relatively short length. Only short queues of packets are stored at the switching centres. This technique is efficient for intermittent bursts of data with pauses in between. Facilities were to include:

Interconnection of different speed terminals.

Interleaved packet interface.

Multiaddress or "broadcast" message facility.

Delayed message delivery.

The new service was to meet the following basic objectives:

Cost attractiveness to the user of remote processing, taking into account users' multiplexers, front end processors and main terminal equipment.

Rapid call set-up, of the order of 100ms.

Range of user rates.

Unrestricted bit sequence of customer data.

International interworking between other networks.

Networks to be digital and capable of integration with other digitized services.

Improved error performance.

Private network digital facility, offering the restricted access but higher performance.

A wholly digital network was considered to give considerable economies in interface equipment, particularly at the higher user rates. Cost savings are likely even for low speed customers but the main benefit was in offering higher speeds and additional facilities. Packet mode studies showed economic advantages to the multiaccess computer operator.

Integration of the transmission plan was foreseen. Separate data switching circuit exchanges (DSEs) were envisaged, for the short and medium term. Processor controlled exchanges were conceived. About 20 such exchanges would service a network of 50,000 users.

A hypothetical terminal distribution for 50,000 terminals was typically assumed as follows:

Basic facility rate	No of terminals
Up to 600 bit/s	30, 000
2.4 kbits/s	16, 000
9.6 kbits/s	2, 500
48 kbits/s	1, 500

Meanwhile, in Spain (Ref 6) studies completed in 1969 led CTNE to open a first generation public data network in 1971. It was based upon conventional computers commercially available which carried out in a centralized way the functions of packetizing, congestion control, signalling, switching, interface handling, and error correction. To quote the author.

"In 1969, we faced a mine field of divided opinion"

Three years later, a two-level topological hierarchy was adopted to accommodate growth. Instead of being merely digital multiplex concentrators, access centres were made to provide interface needs for non-packet terminals. For the third generation starting up in 1982, new access and switching centres have been produced in microprocessor technology to CTNE specifications. Over ten thousand terminals now access the CTNE public data network.

In 1971 in France (Ref 7), the Centre National d'Etudes de Telecommunications (CNET) was programming a three-centre field trial installation using mini-computers linked by 96000 bits per second lines. IRIA was experimenting with scientific computer networks. In the U.S.A. (Ref. 8) there was much interest in the experimental network to become known by the acronym of the agency supporting its development (ARPA). One of the first public service value-added packet mode data networks to support CCITT packet mode Recommendations was developed from some of its technology (TELENET).

5. CCITT RESULTS

As well as new and amended Recommendations of the ten year old V. Series, "Data Transmission on the Telephone Network", in 1972 the CCITT Vth Plenary Assembly approved the start of a new "X. Series" specialized for Public Data Networks (Ref. 9). New terminology describing the new technology was also approved. The first decision (X.1) was that "the known requirements of users could best be served by defined user classes of service". Many new facilities in public data networks were listed "as essential to be available on all international connections (designated "E"). Some additional ones which might be offered by certain networks were designated by "A" (Recommendation X.2).

The Green Book gave CCITT Recommendations for signalling between circuit-switched data exchanges, and for multiplexing. Interface characteristics for terminals had been studied in co-operation with ISO/TC 97. X.21 was the result for synchronous terminals to work with data network circuit terminations. Packet network experimentation was then being considered in some countries. A new question was set for study on that technology, 1972-1976.

By the time of the VIth Plenary Assembly in 1976, packet mode services were being introduced. The first X. Series Recommendations in support of that technology were approved (Ref 10). Several new questions were brought up as the implementation of circuit, packet and hybrid systems provided more experience. During the study period 1976-1980 several new X.Series Recommendations received approval under CCITT Resolution No. 2, "Accelerated Procedure for Provisional Approval of Recommendations". Access from start-stop mode terminals by packet assembly/disassembly facilities (PAD) in public data networks was one requirement to meet user needs. (Recommendations X.3, X.27, X.28).

International connections between packet networks led to X.75. A system of data network identification codes was introduced (X.121). The first of the four digits (DNIC) were assigned as shown in Table 1:

TABLE 1

First digit of data network identification code

0) 1)	Reserved
2) 3) 4) 5) 6) 7)	For data network identification codes DNIC
8)	For interworking with telex networks
9)	For interworking with telephone networks

Three digits are listed in X.121 for each country or geographic location which already has been allocated CCITT numbering code assignments in E.161 (Telephony) or F.69 (Telex). Application by a Member to the Director of the CCITT for a DNIC results in the assignment being published in the numbered series of ITU Operational Bulletins under the heading "Data Transmission Service". The complete DNIC includes a fourth digit under Member jurisdiction which identifies different national networks (see Table 2).

The United States has some twenty DNIC's (Ref 14) for Western Union, ITT, RCA, TRT, Tymnet, Telenet, Graphnet, etc.

TABLE 2 - EXAMPLES OF DATA NETWORK IDENTIFICATION CODES

Canada	3020	(Trans Canada Telephone System) - TCTS DATAPAC network
	3025	International Computer Access Service (ICAS) of Teleglobe Canada
	3029	(Canadian National Canadian Pacific) CNCP Infoswitch network
Hong Kong	4542	C. and W. packet switched network (IDAS ITS)
	4544	C. and W. data access switched network
Spain	2141	international transit node
	2145	special data transmission network via the international transit node
Germany	2623	EURONET (packet-switched data transmission network)
Belgium	2063	EURONET (packet-switched data transmission network)
France	2083	EURONET (packet-switched data transmission network)
	2080	TRANSPAC (packet-switched data transmission network)
	2081	international transit code
United Kingdom	2343	EURONET (packet-switched data transmission network)
	2341	International Packet Switched Service (IPSS)
Ireland	2721	International Packet Switched Service
	2723	EURONET
Italy	2223	EURONET (packet-switched data transmission network)
Luxembourg	2703	EURONET (packet-switched data transmission network)
Netherlands	2042	EURONET (packet-switched data transmission network)

TABLE 3

CCITT V. Series Recommendations (Data Transmission on the Telephone Network)

Section 1	General includes the data alphabet agreed with ISO	7
Section 2	Modems for voice circuits and Interfaces DTE/DCE 300 to 9600 bits per second	19
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Section 1	Services and Facilities	5
Section 2	Interfaces	11
Section 3	Transmission, signalling and switching	15
Section 4	Network Aspects	6
Section 5	Maintenance (test loops)	1
Section 6	Administrative Arrangements (international closed user groups)	1
	CCITT X. Series Total	39

TABLE 4 - SCHEDULE OF MEETINGS

1981		
August	Special Rapporteurs Signalling	Geneva
September	Special Rapporteur Interfaces in packet mode	Paris
October	Special Rapporteurs, - Computer mediated messaging on public data networks - Formal Description Techniques	Ottawa
October	Special Rapporteur, Numbering and Routing	Darmstadt
November	Special Rapporteurs. Reference Model and Transport Services	Morristown N.J.
December	Special Rapporteurs on use of ISDN for Data (WP's VII/1 and VII/2)	Geneva
1982		
March	Working Parties and Special Rapporteurs - Signalling (WP VII/3) (M. Kato) - Network Aspects (WP VII/5) (H. Bertine)	Melbourne
May	Working Parties and Special Rapporteurs - Network Service Classes and Facilities (WP VII/1) (A. Texier) - Network Access Interface (WP VII/2) (J. Wedlake) - Transmission (WP VII/4) (L. Lavendera)	Geneva

6. CURRENT DATA TRANSMISSION AND NETWORK RECOMMENDATIONS

The VIIth Plenary Assembly of CCITT approved a total of 39 new and amended Recommendations in the X. Series (Ref. 15). An equal number in the V. Series (Ref 16) (Data Transmission on the Telephone Network) is grouped under the headings shown in Table 3.

7. CURRENT DATA NETWORKS STUDY PROGRAM IN CCITT, 1981-1984

The VIIth Plenary Assembly entrusted to Study Group VII forty-one Questions. At the Kyoto meeting in April, 1981 (Ref 17) these were assigned to five working parties (Ref 17).

The next meeting of Study Group VII is scheduled for Geneva in December 1982. To avoid falling behind the current pace of implementation and development by network providers and users, a heavy schedule of working party and Special Rapporteur meetings emerged as described in Table 4.:

There is close co-ordination between experts attending different meetings. Studies in co-operation with several other study groups are proceeding as follows:

the use of data networks by Telematic services and Terminals	SG I SG VIII
commonality in numbering	SG II SG XVIII
common channel signalling and System Description Language	SG XI
data transmission on the telephone network	SG XVII
use of ISDN for data	SG XVIII
tariff principles for international connections	SG III
radio aspects of data on satellite services	CCIR

Note: Program reviews with ISO/TC 97 groups took place in Berlin (June 1981) and Geneva (December 1981). ISO experts participated at meetings of Special Rapporteurs in Ottawa, Canada and Morristown, New Jersey, October/November 1981.

The objective of this rushed activity briefly outlined above is to achieve working party reports published next summer, in good time for review by members during the autumn of 1982, so that interim results can be agreed in December 1982. After that there remains the final Study Group VII meeting at the end of 1983, for final draft texts of some 40 new or amended Recommendations in the X. Series.

8. LIMITATIONS OF THIS PRESENTATION

Within the scope of this presentation it has only been possible to give a few examples from this work in CCITT. Many more have been omitted for brevity - such as the developments in the Scandinavian countries and Japan. In particular the experimental European Informatics Network and current Euronet have not been mentioned. Neither have the two competing public data networks in my own country, Canada. Descriptions can be found in the proceedings of many professional Conferences, of the kind given in the references of this paper.

The last three examples (Euronet, Datapac and Infoswitch) are well described in presentations made at an ITU Seminar in Mexico City, March 1981 (Ref 18). Copies of these and other interesting presentations made there are available through the ITU Technical Assistance Program.

9. THE MERGING OF TELECOMMUNICATION AND COMPUTER TECHNOLOGIES (Ref.19)

In his keynote address at Stockholm in 1974, the Deputy Secretary General of ITU noted that a major issue facing the provision of telecommunications services is what other services can be, or should be integrated with telephony. The technical feasibility of integrated digital telephony transmission and switching was already known then. The extent to which digital telephony networks will be used for other services is now a very active subject in telecommunication research and in CCITT.

Mr Butler then went on to point out that formerly there were well defined boundaries between standards for technologies and services of the telephone network and those for digital computers and data processing. Transmission of information in digital form, computer control of sophisticated switching machines and planning for "intelligent" networks was already seen to be merging. Technological inter-dependence in the application of computers to telecommunications was foreseen.

He drew attention to the economic as well as technology grounds for increasing co-operation between telecommunication interests and the computer industry, and hence between ITU and other organizations interested in its work.

Other issues observed in Mr Butler's conclusions are as alive today as they were then. Before fully effective international data communications are available world-wide many issues require further attention such as:

1. The role of advanced communications in economic and social development which has yet to be fully recognized, let alone applied; potentials and opportunities are not fully utilized - even in industrialized countries where there is under-utilization of available technology.

2. The problem of what may be an increasing gap in telecommunications (and in data

communications in particular) between developing and developed countries. Great efforts should be made, he said, to bring others closer to the knowledge and technologies of the developed countries, (ITU presentations such as in Mexico City (Ref 13), Ottawa (Ref 20) and Manilla (Ref 21) recognize this.)

3. There is undoubtedly room for further co-operation between telecommunications organizations, the computer industry, and the semi-conductor industry in attempting to refine and align diverse opinions regarding present and future common requirements. Right decisions will be important for many reasons, not the least of which concern significant capital cost elements in the telecommunication system. These in turn are basic to national and regional development.

10. REFERENCES

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3. D.L.A. Barber and R.A. Scantlebury, "Current and future computer network options", Computer Networks Conference, Infotec London and Amsterdam, January 1971.

4. Herman G. Gabler "Data Network Plánning in the Federal Republic of Germany", IEEE International Conference on Communications, Montreal, Canada, June 1971.

5. G.D. Allery and K.J. Chapman, "Features of a Synchronous Data Network for the United Kingdom", IEEE International Conference on Communications, Montreal, Canada, June 1971.

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9. CCITT Green Book, Volume VIII.

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11. ITU Operational Bulletin No. 179.

12. ITU Operational Bulletin No. 191.

13. ITU Operational Bulletin No. 184.

14. ITU Operational Bulletin No. 182.

15. CCITT Yellow Book, Volume VIII.2 Recommendations X.1 to X.29, and Volume VIII.3 Recommendations X.40 to X.180.

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20. T. Okabe, "CCITT Recommendations on Data and Telematic Services", IRDC Workshop on Computer-Based Conferencing Systems for Developing Countries, Ottawa, October 26-30, 1981.

21. Freiburghaus, MacDonald, Gagliardi and Irmer, Presentations on the work of CCITT SG's I, VII, XI and XVIII, CCITT-CCIR Plan Committee for Asia and Oceania, Manilla, 3-10 February 1982.

BIOGRAPHY

Mr Vern MacDonald, who has been Chairman of CCITT Study Group VII (Data Communication Networks) since its formation in 1972, is currently a senior advisor in the Computer/Communications Secretariat after a number of years as Director, International Telecommunications Systems, Department of Communications. Vern was involved in early development work in data communications at the Northern Electric Research and Development Laboratories, and in telecommunications and radar at the Defence Research Board at Ottawa. In 1965, he established the Government Telecommunications Agency. He has done post graduate work in telecommunications engineering at the University of Ottawa, Carleton University, and the University of Southern Florida, after graduating from the University of Manitoba, and is a member of the editorial board of the journal "Computer Networks".

The CCITT Reference Model

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Since 1978 the CCITT and the ISO have been engaged in parallel developments of a Reference Model for Open Systems Interconnection. The purpose of this Model is the definition of services, protocols and structure of communications systems that permit exchange of structured data between heterogeneous systems. Standards derived from the Model will involve the semantics of services and both syntax and semantics of protocols. The ISO document has reached the stage of a Draft Proposal and the CCITT draft is nearing the stage of a Draft Recommendation. Effort has been expended on establishing functional identity between the two versions of the Model and success seems at hand.

This talk will describe the historical development, current status and technical details of the Reference Model with emphasis on the relationship of the Lower Layers of the Model to existing CCITT Recommendations and ISO Standards and on the potential requirements for protocol and service specification Recommendations and Standards at the Higher Layers of the Model. A brief summary of the results of the just concluded Meeting of the CCITT Special Rapporteur's Group on Layered Models will be presented.

1. INTRODUCTION

The International Telegraph and Telephone Consultative Committee (CCITT) of the International Telecommunications Union (ITU) has, over the years, provided those standards necessary to permit effective international interconnection of various telecommunications services and facilities. With the advance of technology, the facilities requiring interconnection have become more and more elaborate and complex. Past techniques for the development of standards no longer suffice. It is no longer sensible to identify particular problems, isolate them and construct standards (CCITT Recommendations) to meet the specific needs. A broad spectrum and co-ordinated collection of interrelated Recommendations is now essential.

As devices that must be interconnected increase in sophistication from the relatively simple telephone hand-set to electronic computers and even collections of such systems themselves interconnected by a local network, the requirement for a family of Recommendations is apparent.

In the present instance, the required family of standards is not composed solely of telecommunication standards, all of which can be encompassed by CCITT Recommendations, but, rather, must borrow from standards developed outside the CCITT purview, in particular, standards developed by organizations such as the International Organization for Standardization (ISO) in the area of information processing.

In order to provide the necessary coherence to such a family of standards, models must be developed that describe the total process involved so that the various standards in the family can be seen in their relationship, one to another, and can be made to interwork properly.

At present there is substantial interest in the area of Public Data Network Applications; that is, providing the ability to interconnect disparate and dissimilar end points, or "users", which may be computers, peripherals, terminals, their associated software, human operators or physical processes. Such interconnection must be independent of both the details of the nature of the end points and the semantic content of the application being performed. This has led to the CCITT's recognition of the need for a Reference Model for Public Data Network Applications.

The CCITT is not alone in this recognition, of course. The ISO is also in the process of developing its own Reference Model with essentially the same purpose. Among the major concerns of both the CCITT and the ISO is the establishment of consistent if not identical models. These models are sufficiently complex, however, that it will be difficult if not impossible to determine their consistency or identity without a common descriptive methodology.

Communications systems which conform to the standardized protocols derived from the model are sometimes referred to as "open systems" and such interconnection is, thus, "open systems interconnection". The term used by ISO to identify its model is the "Reference Model of Open System Interconnection (OSI)".

It is important to understand that the Reference Model is precisely what it says it is, a model. Systems do not conform to the model, networks do not conform to the model, only protocol specifications and service specifications conform to the model. This phenomenon is not a novelty to the CCITT where there have been Recommendations that are only meaningful to the development of other Recommendations. I have been unable, however, to identify any ISO standards where the only things that can be said to comply with them are other ISO standards. This is an important point when arguments arise about the need for describing the standard or Recommendation in language that can be understood by the users. The only users of the Reference Model (be it ISO's or CCITT's) will be designers of protocol standards and service specifications.

2. HISTORY

Recognition of a need does not always bring immediately in its train satisfaction of that need. There was no handy Reference Model for Public Data Network Applications sitting quietly on the library shelf when the CCITT Study Group VII determined the requirement for one in 1978 April. There was no formal Question on the subject - there hardly could have been, the idea had not even been invented in 1976. Study Group VII followed usual practice and established an Interim Rapporteur's Group to develop a formal Question for the next (1981-1984) Study Period. Additionally, correctly anticipating positive action at the CCITT Plenary in 1980 November, the Rapporteur's Group began direct work on the subject itself.

Given that charge, the Interim Rapporteur's Group was established. It met five times: Rennes, France (1978 October), Nurnberg, Germany (1979 February), San Franscisco, USA (1979 September), Brighton, England (1980 May) and Ottawa, Canada (1980 October). Then the formal Question 27/VII was approved, a Special Rapporteur was appointed and official study of the Question began. The Special Rapporteur's Group has met twice since then, Morristown, USA (1981 November) and Melbourne, Australia (1982 March).

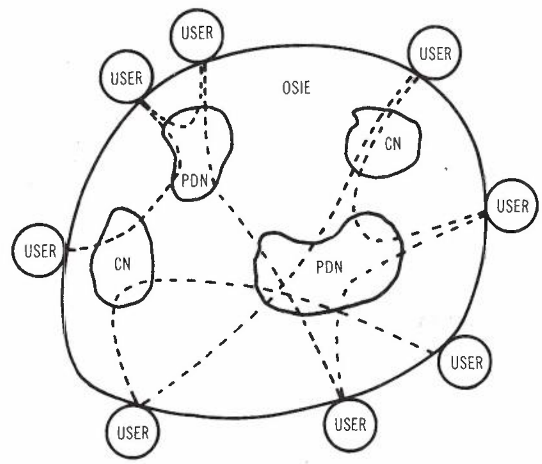
Initially the Interim Rapporteur was Mr. Paul Baratelli of AT & T; since his retirement from the activity in 1980 February, the author of this paper has served as Rapporteur. The work of the Group is far from complete as yet. From the San Francisco meeting the topic was separated into two activities, the Reference Model per se and the Transport layer work under Mr. Keith Knightson of British Telecom. The work discussed here is limited to the Reference Model.

In all but its most global aspects the work was reset to zero at the Brighton meeting where the decision was taken to come as close to the ISO Model as was feasible. At the Morristown meeting a further decision was taken, aimed at the implementation of this principle, to adopt as a basis for the actual detailed description of the Model the correspondent text of the ISO Model and only make required changes.

Progress in the development of the Reference Model has been detailed in the attachments to the various meeting Minutes (Refs 1-4) and in a variety of papers too numerous to cite. It is difficult to estimate the true number of contributors; perhaps as many as two hundred expending as much as fifty man years. It is truly neither a trivial nor inexpensive undertaking.

3. THE REFERENCE MODEL

The Reference Model applies to the interconnection of users requiring access to resources within the jurisdiction of at least one other user. As noted, a user of the communications system covered by the Reference Model may be a computer, peripheral, terminal, the associated software, a human operator or a physical process, that forms an autonomous whole capable of determining its own particular communications needs.



OSIE = OPEN SYSTEM INTERCONNECTION ENVIRONMENT
PDN = PUBLIC DATA NETWORK
CN = COMPATIBLE NETWORK

Figure 1. Model of Telecommunications Networks.

Interconnection and resultant exchange of information between users is performed by telecommunications networks (see Figure 1). The ISO model contemplates the possibility of non-electronic transport mechanisms, but the CCITT regards this as outside its province and there remains a possibility that this will result in a difference between the two models. In the CCITT view, the networks principally considered are Public Data Networks, possibly in tandem with one or more other networks which are compatible with the standards for Public Data Networks, such as various private and local networks.

It must be emphasized again that the Model is a Model, not an implementation architecture. Conformance with the Model does not imply any particular network implementation or technology, only that the protocols involved and the services offered are consistent with those derived from the Model and developed elsewhere as Recommendations. To quote Korzybski on this point, "The map is not the territory".

The Reference Model for Public Data Network Applications is an abstraction, but it cannot live in total isolation. There must be a mechanism for relating it to the real world of telecommunications. We start with a view of the users (and their associated application processes) lying in a local system environment (LSE) which is outside the model. It is important to recognize that the users themselves are outside the model and interface with it through the services provided to the user. These services might be invoked in many ways, such as strokes on a keyboard or procedure invocation in a programming language compiled into a series of specific computer instructions. It is these services that connect the users to the mechanism that implements the services provided by the Model. Strictly speaking, the physical media that perform the real transfer of electrical signals are also outside the Model. Thus, there is an abstract Open System Interconnection Environment (OSIE) which is the Model as well as some real Open System Interconnection Mechanism (OSIM) which implements the services and exchanges the protocols that are defined by means of the Model.

Each user will have access by way of its Local System Manager (LSM) - in the usual data processing context part of the operating system - to an effectuator of the processes that invoke the services of the OSIE. This situation is depicted in Figure 2 for the case of two-party communication. Here X and Y are the users as reflected in their respective application processes, residing respectively in System A and System B. Each has its own LSM and effectuators of the OSIE. The sole apparent connection between X and Y is seen to be the OSIE itself, and, thus, all communication between X and Y is by way of the OSIE.

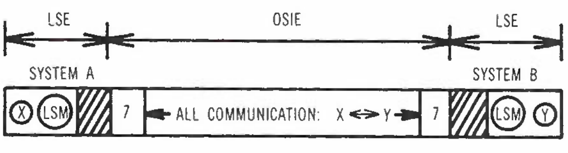


Figure 2. Model of system for communication between users X and Y.

The key observation to make about Figure 2 is that all that the users of the Open System Interconnection Mechanism can see of the process of communication is what is there shown. Each user is aware of itself, its own LSM, the effectuating mechanisms (shadowed boxes) of the OSIE services, either directly or via its LSM, and finally, a view of its communicating partner through the window of the OSIE to which it has access (the white boxes labelled "7"). It sees its partner in a constrained fashion, of course, but except for the specific services offered, the user does not see any other part of the Open System Interconnection Mechanism.

The process of interconnection and the subsequent communication that is then permitted is a complex process, however. Indeed, there are many aspects of that process of which the user either needs not or must not be aware. Such matters as data format matching, whether it be simple code conversion or the most elaborate mappings of data structures from one data model to another, transmission speed impedance matching, flow control, various methods for detecting and correcting errors in transmission, routing through the complex of networks and nodes, and transmission medium selection are a nuisance to the user and irrelevant to his main concern. In some cases such as encryption and decryption there are times when the service provided is none of the user's business. It is these services and the functions that provide them that Open Systems Interconnection via the Public Data Networks makes available to the users, and it is the exercise of these functions that is modelled by the Reference Model for Public Data Network Applications as will be explicated in the CCITT Recommendation.

A typical prescription for solution to complex problems is partitioning in order to develop a structured result. This is the technique employed for the Reference Model for Public Data Network Applications and it is known as "layering". Seven distinct layers have been identified as given in Table 1.

TABLE 1 - REFERENCE MODEL LAYERS

1. Physical Layer
2. Data Link Layer
3. Network Layer
4. Transport Layer
5. Session Layer
6. Presentation Layer
7. Application Layer

Thus, the full picture of the Open System Interconnection Environment and its surround is an elaboration into the seven layers, the effectuators of the functions of those layers and the actual medium of transmission. This is shown in Figure 3.

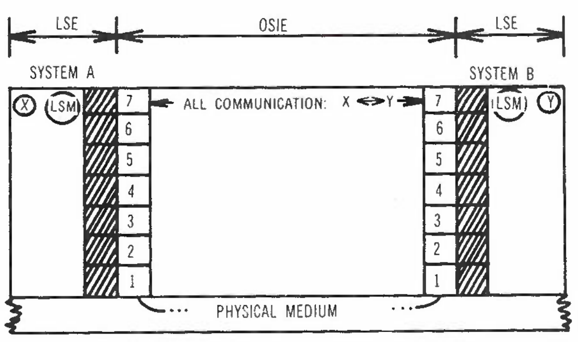


Figure 3. The Open Systems Interconnection Environment and its surround.

All the Model recognizes is the existence of the users as reflected through their LSMs and those properties relevant to the communication that are passed into the OSIE by the effectuators of the Application Layer of the Model which call upon the services provided by the OSIE. The logical presence of the physical medium is all that the Model perceives about the transmission medium itself. Thus, the correct view of the Model itself is that shown in Figure 4.

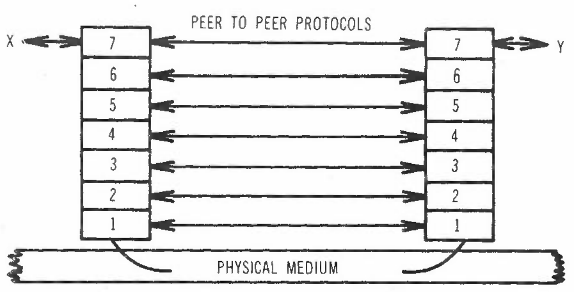


Figure 4. The Open Systems Interconnection Reference Model for Public Data Network Applications.

This picture is identical to that found in the ISO Reference Model of Open System Interconnection (5), and to this level of detail the two Models are unquestionably identical. As yet both models are described only in English prose and so it is not clear whether there are substantive differences in detail or not. There probably are; the likelihood of two different groups arriving at identical specifications is quite small in anything this complex.

In brief, the functions performed by the seven layers are:

1. Physical Layer - the physical layer is the most basic level of the Model and transmits transparently a bit stream over a circuit built in some physical communications medium.

2. Data Link Layer - the data link layer overcomes the limitations inherent in physical circuits and does error detection and correction, masking the deficiencies in raw transmission quality.

3. Network Layer - the network layer delivers data transparently, selecting a route and switching the data accordingly.

4. Transport Layer - the transport layer transfers data transparently in a reliable and cost-effective manner, optimizing the use of resources according to the nature of the communication, and can be viewed as a data conduit that leads from one end point to a destination end point, independent of the nature and number of intervening real networks.

5. Session Layer - the session layer co-ordinates the interaction within each association between corresponding users, matching the users to the transport.

6. Presentation Layer - the presentation layer translates and transforms data which is to be transferred into a form recognizable by the corresponding recipient user.

7. Application Layer - the application layer specifies the nature of the communication required to satisfy the users' requirements as reflected in service requests from the user.

4. SCENARIO OF INTERCONNECTION

The following scenario of interconnection illustrates how the Model is to be interpreted. Assume that some user, X, residing in System A, wishes to exchange some structured data with another user, Y, residing in System B. In order for such an exchange to be considered via Open System Interconnection, both X and Y must have announced their availability to the Open System Interconnection Mechanism through the process of enrolment. Abstractly this means that some directory mechanism accessible throughout the OSIE must be advised of a global name for each. This process may or may not be performed through the ordinary communication mechanism and it may or may not be centralized. In the latter case, the global name may be constructed by concatenating the local name to the name of each local name domain.

If the process is to proceed via the OSIE itself, the process is identical to that described below except, of course, the directory (global or local) is already presumed to be announced and its name known. Assuming that the directory itself is distributed, it is only necessary that the announcing process know the name of its local directory and that each component of the directory knows sufficient names of other directory components to provide a connected graph of directory components.

Given the announced availability of X and Y, X may initiate communication with Y via the OSIM by: (1) providing a sufficient description of Y (name, collection of attributes, etc.) to the directory to select the unique global name of Y so that it may be communicated to X; (2) constructing, via its LSM, an initial application layer protocol which specifies Y by that global name and contains the relevant parameters of the communication as seen by the application process itself (e.g., required response times, maximum tolerable error rate, constraints on acceptable carriers, resource utilization information desired, etc.); and (3) sufficient characterization of the syntax of the data to be exchanged to permit the construction of a presentation layer protocol adequate for the exchange of meaningful data.

In order for the information contained in the initial application layer protocol generated on behalf of X to be communicated to the local system manager in system B so that it can be interpreted on behalf of Y, the presentation layer processes in system A must ensure that the encoding and format of this protocol are in such a state as to be interpretable by the presentation layer processes in system B. Any necessary transformations, either to a syntax known by A to one known to B, or to a standard syntax known to the OSIE and therefore necessarily known to B, occur in the initial application system protocol at this point.

Relevant parameters of the communication and the (now properly encoded) application layer protocol are passed from the presentation layer in system A to the session layer in system A. The session layer processes in system A construct a session layer protocol, necessarily in a standard syntax of the OSIE, describing the parameters of the session that X desires to initiate with Y. As part of the process of announcing Y's availability to the OSIE, Y was assigned a uniquely identifiable session functional unit responsible for the establishment of sessions with Y. The session functional unit assigned to X can determine via a directory the proper transport address for the session functional unit assigned to Y, and that address is provided to the transport layer in system A.

The transport layer in system A, via invocation of the lowest three layers (network, link, physical), establishes a transport connection meeting the specified parameters of the communication (if possible) between the session functional units associated with X and Y in systems A and B respectively. The session, presentation and application layer protocols generated in system A on behalf of X are then transmitted to the session functional unit associated with Y in system B via this now established transport connection.

The session layer in system B, upon verification of its ability to establish a session commensurate with the requested parameters, invokes the presentation layer in system B. The presentation layer verifies its ability to provide the requisite transformations and invokes the application layer in system B. The application layer in system B, via the local system manager in system B, establishes the application process to application process communication between X and Y as intended.

It is now possible to: (1) exchange application specific protocols between X and Y via the application layer functional units in systems A and B to establish the semantic context of the communication; (2) exchange data between X and Y; and (3) terminate the communication when desired.

At any stage in this interconnection process, it must be possible for any layer to announce, via a protocol, such things as the inability to continue under the initial parameters and, possibly, provide an alternate set of parameters under which it can continue. If its peer determines that the alteration is acceptable, the communication can proceed with the altered parameters. This determination may involve the concurrence of the next higher layer if alteration of service will result from the changed parameters. Such negotiation can occur at any time.

5. FORMAL DESCRIPTION OF THE REFERENCE MODEL

It is beyond the scope of this paper to discuss in detail the possible methods of formally describing something like the CCITT Reference Model for Public Data Network applications, but a sketch of some ideas is desirable in view of the importance of the subject. It would appear that only through the existence of a formal description will it be possible to determine if the CCITT Model and the ISO Model are identical or equivalent and, if not, to pinpoint the differences.

It seems clear that if the Reference Model is to have any strict meaning beyond a useful device to focus informal conversation about a complicated subject, it will be necessary to specify <u>all</u> the services provided to each next higher layer by the layer below, including those provided from the physical medium to the physical layer and those provided by the application layer to the user. From these service descriptions it should then be possible to <u>deduce</u> the semantics of a complete protocol for each layer. A direct way of accomplishing this is to specify exactly the functions performed in each layer together with their permissible compositions, that is, the sources of the function arguments and the sinks of the function values. Any function may get its arguments from: (1) another function in the same layer, (2) from a function in the next higher layer (request to the layer for a service), (3) from a function in the next lower layer (response to the layer from a service request), and (4) from a function in the same layer but in a different system (via a protocol element). . Values may flow in the same four ways.

There are several ways of precisely specifying functions conceived as sets of ordered pairs such as tables, closed expressions and algorithms. Any one will do. An incidence matrix will suffice to indicate the compositions permitted. A full formal description of the Reference Model can be constructed in such terms.

There are many alternatives and which one CCITT will select has not even been discussed in great detail. However, it <u>has</u> been agreed that some formalism will be chosen and used as the official specification of the Recommendation, and the CCITT has urged the ISO to undertake the same exercise and this urging has been adopted. Comparison will then become a mathematical exercise instead of a shouting match.

6. REFERENCES

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BIOGRAPHY

Thomas B. Steel, Jr. is with the Standards Planning Group of the Marketing Department in the American Telephone and Telegraph Company and is currently responsible for the co-ordination of development of corporate strategies concerning national and international industry standards in telecommunications and data processing. He is an active member of CCITT. In addition, he is the CCITT Special Rapporteur on the Reference Model for Public Data Network Applications, an active participant in several ISO Working Groups and is a Member of several ANSI technical groups. He has vast experience at the forefront of computing development over 30 years.

Evolution of the X25 Interface

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British Telecom

The International Telegraph and Telephone Consultative Committee (CCITT) issued its first Recommendation (X25) relating to Public Packet Switched Networks in 1976 (1).

During the CCITT Study period 1977-1980, consideration has been given to elimination of possible network differences in order that the manufacturers of Data Terminal Equipment can be assured of uniform operation of their equipment on all X25 based networks.

A revised CCITT Recommendation X25 was approved in February 1980 (2) and it is envisaged that all Public Packet Switched Networks will conform to this revised version by 1982.

This paper discusses the revisions made to X25 since 1976 that now make the provision of an X25 universal interface feasible and which can at the same time accommodate Data Terminal Equipments of varying degrees of sophistication. The Fast Select and Datagram enhancements are outlined. The future possible extensions to X25 already under discussion in the CCITT Study period 1981-1984 are detailed. A table of available and planned X25 networks is given.

1. INTRODUCTION

Recommendation X25 defines the interface between the Data Terminal Equipment (DTE) and the Data Circuit-Terminating Equipment (DCE) for terminals operating in the packet mode on Public Data Networks.

The DTE is the equipment provided by the user and the DCE is the co-operating network component(s) providing the packet switched service.

Since 1976 CCITT Study Group VII has continued to refine X25 in co-operation with other standards organisations, DTE manufacturers, and users, in order to resolve network implementation differences. This work has not only resulted in elimination of network differences, but has produced some valuable enhancements and new user facilities.

2. UNIVERSALITY

The provision of universality has been resolved in 2 ways:-

a. by the definition of universally available defaults for network parameters;

b. by upgrading certain facilities, which had been previously optional, to mandatory, and by adding new mandatory facilities where necessary.

The facilities are summarized in Figure 1.

A DTE can thus operate with a common default sub-set, or with the total parameterised set that will be common to all networks, and be assured of uniform operation on all networks.

3. X25 PHYSICAL LEVEL

No changes have been made to the specification of the physical level. Currently all networks support X21 bis and data signalling rates of 2.4, 4.8 and 9.6 kbit/s. Provision of 48 kbit/s may not be universal but all networks will offer a data rate in the same region (eg 56 kbit/s).

Minor variations in data signalling rates are not vitally important in any case, since no procedural or electrical difference exists, and provided the DTE always takes its clock from the DCE. The flow control procedures of X25 will smooth out any speed variations between the two ends of a virtual circuit.

4. X25 LINK LEVEL

The Link Access Procedure (LAP) specified in 1976 was not subsequently approved by the International Standardisation Organisation (ISO) who had no suitable procedure within the High-Level Data Link Control (HDLC) procedures repertoire at that time. ISO subsequently proposed a different set of elements which provoked a great deal of controversy at the time (1977).

In accordance with agreements on CCITT and ISO collaboration a joint CCITT/ISO meeting was convened in 1977 to produce a mutually acceptable solution for the HDLC procedures to be used for the DTE-DCE link. This resulted in the 1977 revision of the link level for X25 to

FACILITY	TYPE	REQUEST OPTION	UNIVERSAL DEFAULT
Closed User Group	E	In Call Request Packet	
Throughput Class Negotiation	E	In Call Set-up Packets	Speed of access link (Dataline)
Window Size	E	In Call Set-up Packets	2
Packet Size Negotiation	E	In Call Set-up Packets	128 octets
Reverse Charging	A	In Call Request Packet	-
Fast Select	A	In Call Request Packet	-
Bilateral Closed User	A	In Call Request Packet	-
RPOA Selection	A	In Call Request Packet	-

FACILITIES AGREED AT SUBSCRIPTION TIME FOR AN AGREED PERIOD OF TIME

Reverse Charging Acceptance	(A)	Fast Select Acceptance	(A)
Incoming Calls Barred with CUG	(A)	Outgoing Calls Barred with CUG	(A)
CUG with Incoming Access	(A)	CUG with Outgoing Access	(A)
One-way Logical Channel Incoming	(A)	One-way Logical Channel Outgoing	(E)
Incoming Calls Barred	(E)	Outgoing Calls Barred	(E)
Packet Retransmission (DTE use of REJ)	(A)		

Note: E indicates availability on all networks.
A indicates availability on some networks.

FIGURE 1 - SUMMARY OF FACILITIES

include a new set of procedures known as the asynchronous balanced class of procedures and designated LAPB. Some minor changes have taken place since 1977 to allow symmetrical operation. Symmetrical operation allows the DCE to use the same repertoire of commands and responses as the DTE. This aspect is of particular importance to networks which intend to offer LAPB only.

X25 now states that LAPB is the preferred mode of operation and this could be available on all networks by the end of 1981 and all subsequent new networks.

It should be noted that networks currently providing LAP will continue to support LAP, even when LAPB becomes available, for several years.

It follows therefore, that LAPB now provides the universal link level interface. The symmetry now provides compatibility between DTE/DCE and DTE/DTE operation (important for circuit switched or leased line operation).

From the implementation point of view, it has been observed that all HDLC implementations (known to the author) are octet oriented. This arises from the available hardware, and the need for simplification of software, and the practical need for application standards. This is not to say that the bit orientation of the framing mechanism is redundant. In fact, the major advantage of the framing mechanism is its capability to recover from 'bit slip' errors which require a bit oriented recognition mechanism.

The issue of bit/octet orientated information fields is still under study, but for the sake of universality octet orientation should be assumed, not only from network considerations but from the point of the Open Systems Interconnection (OSI) aspects. Studies in the OSI area indicate that data representation should be dealt with at a much higher level in the architectural hierarchy. This aspect is particularly important when a given link is operating with a dynamically changing multiplex of information arriving from a geographically diverse set of sources and application.

5. X25 PACKET LEVEL

The major enhancements/changes made since 1976 to provide universality are shown in Figure 2.

YEAR	CHANGE/ENHANCEMENT
1977	End-to-end diagnostic fields
1978	National Facility marker Formatting extension policy New call progress signals
1979	Incoming Call Timeout Diagnostic codes Diagnostic packet Delivery Confirmation (D) bit Packet and Window Size Negotiation Throughput Class Negotiation Logical Channel Assignment Rules Octet oriented Data Field Universal parameter defaults Fast Select - Datagrams

FIG. 2 - CHANGES TO X25 SINCE 1977

5.1 Diagnostic Fields. These field are added initially to enable DTEs to convey appropriate information in Clear, Reset and Restart packets.

More recently they have been adopted for DCE usage also, to permit more explicit reasons to be associated with the network generated cause fields of Clear, Reset and Restart packets. A table of diagnostic codes has been produced, numbering about 50 so far, and categorised according to the cause type.

A DTE does not need to supply a diagnostic code field. The DCE will always deliver such a field, however, with a zero value if a packet generated by a remote DTE did not include this field.

5.2 National Facility Marker. This was added to permit national enhancements which either could not be agreed by, or were required prior to, CCITT agreement. The need for this feature has been decreased by the new revisions, however, and is not relevant to the concept of universality but it is mentioned here for the sake of completeness.

5.3 Formatting Extension Policy. The format of Call Accepted and Call Connected packets has been extended to permit address and facility fields. A DTE does not have to supply such fields; the DCE on the other hand will always supply these fields. The extension was made to permit facility negotiation between calling and called DTEs, and negotiation by the DCE if necessary. The need for this feature will be clear from later consideration of X25 facilities.

This enhancement led to a basic policy for formatting extensions, that DTEs should be designed to be tolerant of extra fields and ignore them if necessary. In this way the standard can be enhanced piecewise without affecting DTE design (unless of course they wish to take advantage of the enhancement).

5.4 Call Progress Signals. New call progress signals have been added to reflect the new facility enhancements and need to be handled by the DTE.

5.5 Incoming Call Time-out. The time allowed for the called DTE to respond to an incoming call has been allocated a minimum of 180 seconds. This will assist DTE implementors in deciding universal time-out values.

5.6 Diagnostic Packet. This is a new packet type designed to assist error handling. It is not part of the universal interface but it is mentioned here for completeness and as a warning to DTE implementors to ignore unknown packet types if universal operation is to be achieved.

5.7 Delivery Confirmation (D) bit
Packet/Window Size Negotiation
Throughput Class Negotiation

The above items are concerned with one of the most contentious areas, namely that of significance of acknowledgement and confirmation packets, and a great deal of work on this issue has resulted in a series of enhancements. The contention originated from the fact that X25 had only defined procedures for the local DTE/DCE interface and 2 types of network had actually been implemented prior to 1978.

One type of network operated on a link-by-link basis and the other on an end-to-end basis. These networks are said to exhibit the characteristics of local and end-to-end significance respectively.

With local significance, packets are acknowledged, in general, by the local DCE without direct reference to any intermediate network component or the state of the remote DCE/DTE interface. Thus for data packets flow control can only be exerted by means of accumulated back pressure.

With end-to-end significance it is the responsibility (within acceptable limits) of the remote DTE to return the appropriate acknowledgements, which are conveyed back across the entire network connection to the originating DTE.

For the data contained in data packets the P(R) value contained in Data, RR, RNR or REJ (where employed) provides the acknowledgement, and control packets (eg clear, reset) are acknowledged by the appropriate confirmation packet.

Advocates of local significance claim that the achievable throughput is independent of the transit delay and less dependent on packet and window sizes, and that operation with a packet size of 128 octets and a window size of 2 should normally be adequate. This will be true if the required throughput can be requested from the network. The number of packets in the network, however, at any given instant is non-deterministic, and any true acknowledgement procedure will have to be implemented at a higher level.

Advocates of end-to-end significance consider that acknowledgements from the remote DTE are advantageous, citing economic and recovery considerations. Transit delay, however, has to be taken into account for a given throughput and packet and window sizes must be adjusted accordingly.

The D bit proposal is a package of enhancements to meet the requirements for both local and/or end-to-end significance.

The D bit proposal permits selection of significance on a per packet basis by the transmitting DTE. This is achieved by setting bit 7 of the first octet of the packet header to 0 for local significance and to 1 for end-to-end significance. Clearly, this meets one objective, but in addition there must now be appropriate mechanisms to achieve a given throughput according to the setting of the D bit.

Two facilities are required:-

a. Throughput class negotiation, to be used for local significance.

b. Packet and window size negotiation for use when end-to-end significance is in operation.

Negotiation of the actual values takes place via the format extension referred to earlier. Note that now the receivers can negotiate according to their resource capabilities. Universal defaults will apply in the absence of specific requests or other subscription defaults.

The universally available defaults will be a packet data field size of 128 octets and a window size of 2, and a throughput class equal to the speed of the access line as shown in Fig. 1.

Thus some facilities which had previously been optional (A category) are now mandatory (E category), ie offered by all networks, and have been enhanced to allow negotiation for the benefit of the receiving element of the DTEs.

Whilst this at first sight may seem complicated, it does provide a universal interface for both future and existing DTEs, and can accommodate both simple and sophisticated DTEs.

5.8 Logical Channel Assignment Rules

The ordering of the various logical channel types has been agreed as shown in Fig. 3.

CHANNEL NUMBER	CHANNEL TYPE	
0	Reserved	
1 – HPVC	Permanent Virtual Circuit Channels and Datagrams	
LIC – HIC	One-way Incoming Channels	Virtual Calls
LTC – HTC	Two-way Channels	Virtual Calls
LOC – HOC	One-way Outgoing Channels	Virtual Calls
4095		

FIGURE 3 - LOGICAL CHANNEL ASSIGNMENT RULES

Logical channel types may be partitioned at subscription time and the boundaries of each type defined. The use of the first 4 bits of the local channel number (the logical channel group number) may be used to define the lower boundaries of each type.

It has been agreed that single channel DTEs will use logical channel number 1. This ensures universal compatibility between single and multi-channel DTEs on all networks.

5.9 Fast Select (A Facility). The objective of the Fast Select facility is to permit user data to be associated with the call establishment packet. This permits small amounts of data, up to 128 octets, to be transferred without the necessity to enter the data transfer phase of X25, and is considered suitable for transaction oriented applications.

Currently there are 2 varieties of fast select, one with restricted response, the other without restricted response, which can be indicated in the Call Request packet.

With the restricted response option, the called DTE is only permitted to respond wtih a Clear Request packet with data.

When restricted response is not invoked the called DTE may respond with either a Call Accepted packet with data or a Clear Request with data.

Normal virtual call procedures apply after transmission of the Call Accepted packet.

5.10 Datagrams (A Service). Datagrams were added also to accommodate transaction oriented applications. Whereas the Fast Select facility uses standard call set-up procedures the Datagram Service has no concept of call set-up.

Instead a certain logical channel (or channels) may be assigned solely for carrying datagrams. Datagrams are units containing user data of up to 128 octets and each unit also contains both the calling and called address and associated facility requests (eg delivery confirmation etc).

6. DTE IMPLEMENTATION CONSIDERATION

A simple DTE may operate using the universal defaults and minimum packet formats common to all networks.

A sophisticated DTE may take advantage of the full range of facilities offered by all networks.

Some ways of realising a universally applicable implementation are discussed below. Provision of the revised 1980 version of Recommendation X25 is assumed.

6.1 Link Level. A DTE need only implement LAPB. Parameters N1, N2, and T1 may be set to constants, and K set to 7, for all networks.

Only octet oriented fields should be transmitted. Non-octet data structures should be accommodated within an octet oriented information field by employing suitable higher level protocol and formatting techniques.

6.2 Packet Level. Single call DTEs should use Logical Channel Number 1. Multi-channel DTEs should also use Channel 1, with types ordered as per Figure 3. Channel 0 should be avoided. Provision should be made for accommodating arbitrary values for the lower and upper bounds of channel type groups.

Simple DTEs can employ minimum packet formats, but must be prepared to receive extended formats, and ignore them without assuming error. In this way compatibility will always be assured for future extensions. Similarly DTEs which do not generate diagnostic fields should be prepared to receive them, and also ignore if necessary.

The DTE should decode the packet type identifier first, and ignore unknown types (not enter error condition). This will allow uniform operation even when new packet types are added.

Address formats may vary but will always have the correct length declaration. DTEs need only generate the called address, but should be prepared to receive both calling and called addresses. Account should be taken that a received address may:-

a. contain sub-address digits;

b. be different from the original called address in cases where the network has re-directed the call.

The facilities field need never be used by simple DTEs that are using default characteristics. They should, however, be prepared to receive facility fields. These can be ignored by simple DTEs since they can only contain the same universal default values. This arises because the DCE negotiates on behalf of the DTE where necessary.

Sophisticated DTEs may use all of the mandatory network facilities.

DTEs should be prepared to respond to an incoming call within 3 minutes.

Since not all networks provide the packet retransmission facility, a DTE should cease transmission of data packets when a RNR packet is received.

The rate at which acknowledgements [P(R)] are returned will affect the throughput especially when the D bit is set for end-to-end significance.

If the DCE receives a RNR from the DTE, the DCE will cease transmission of data packets as quickly as possible. However some safety margin should be allowed since there may be packets in the link level transmission queue which cannot be prevented from transmission.

DTEs may always operate with the universal default packet data field size of 128 octets and a window size of 2.

Even single channel DTEs should be capable of handling Clear, Reset and Restart procedures. This will give commonality with the multi-channel DTE procedures, and ease the upgrading of a single channel DTE to become a multi-channel DTE.

7. X25 NETWORKS

The number of X25 networks throughout the world has steadily increased over recent years.

Figure 4 below shows existing and planned national public packet switched data services.

COUNTRY	DATE OF SERVICE
Austria	1982
Australia	1982
Belgium	1981
Canada (Datapac)	1977
(Infoswitch)	1978
Chile	1981
Denmark	1983 #
Finland	1983
France	1978
F R Germany	(1979)+ 1980
Greece	1981 +
Hong Kong	1980
Ireland	1983
Israel	1982
Italy	(1979)+ 1982
Japan	1980
Luxembourg	1981
Malaysia	1982
Mexico	1981
Netherlands	1982
New Zealand	1982
Norway	1980
Portugal	1983
Singapore	1981
Spain	1981
Sweden	(1979)+ 1982
Switzerland	(1980)+ 1982
UK	(1979)+ 1980
USA Telenet	1975
Tyronet	1970

Under consideration.
+ Single node in advance of full public service.

National Public Packet Switched Services

FIGURE 4

8. FUTURE POSSIBLE EXTENSIONS

The following items are still currently under study as possible extensions to X25:-

1 Connection to Private Networks

Items related to this issue are addressing and private network generated progress and diagnostic signals.

2 Redirection of Calls.

The issues relate to permission for and indication of redirection and associated reasons.

3 Access To/From the PSTN

The requirements for parameter selection, both at link and packet level, and calling party identification are under study.

4 Multilink Procedure

This study includes possible incorporation of the X25 multilink procedures.

5 Charging Indication

This study involves agreeing procedures and formats for providing the customer with charging information when a call is cleared.

6 Hunt Group Facility

7 Use of modulo 128 sequence numbering at the link level.

This may involve revision of the SREJ procedure.

9. CONCLUSIONS

This paper has illustrated the practicability of X25 being regarded as a stable and universal interface to public packet switched networks on a world-wide basis.

The number of networks, the stability, and the now universal nature of the interface, make X25 a practical proposition for global interconnection and should remove any doubts from DTE implementers regarding the world-wide applicability of X25 for their products. The way is finally open for users to achieve world-wide communications at reasonable cost.

10. REFERENCES

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3. Rybczynski, A.M., et al, "A Common X25 Interface to Public Data Networks", Computer Networks Journal.

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BIOGRAPHY

Keith G. Knightson is Head of Standards and Protocols Group in the Digital Data Networks Division of British Telecom. He has been an active participant in CCITT in the development of the packet-switching Recommendations. He also is involved with Open System Interconnection Standards both in CCITT and ISO, and is currently the CCITT SG VII Special Rapporteur for the Transport Service, Transport Layer, and Network Service. He was actively involved with specification and implementation of BT's Packet Switched Service (PSS) and value-added services, and the UKs earlier Experimental Packet Switched Service (EPSS).

Keith holds both a B.Sc. and an M.Sc. in Computer Science, is a Chartered Engineer, and a Member of the Institute of Electronic and Radio Engineers.

The Transport Layer

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The importance of the Transport Layer in the OSI model will be explained and active standards bodies identified.

The architectural aspects of the Transport and related layers will be described and the objectives of the Transport Layer will be outlined. Quality of Service parameters will be introduced.

The concepts of an abstract service will be used to explain the use of the set of service primitives.

The relationship between functions and protocols will be identified, leading to the concepts of protocol classes. The common functionality and the individual functionality of the various classes will be briefly described, together with the encoding principle.

1. INTRODUCTION

One of the essential requirements within an Open System Interconnection environment is the ability for one open system to communicate with another geographically remote open system.

The Transport Layer of the OSI Reference Model (1) is the one and only layer in the architecture with the overall responsibility for controlling the transportation of data between a source end-system and a destination end-system. The Transport Layer has thus been the subject of intense activity over the last few years.

2. INTERNATIONAL ACTIVITIES

The 3 following organisations are active in producing standards for the Transport Layer:-

European Computer Manufacturers Association - ECMA

Comite Consultative Internationale de Telegraphie et Telephonie - CCITT

International Organisation for Standardisation - ISO

ECMA was the first international standards body to produce and ratify a Transport Protocol which has been published as Standard ECMA-72(2).

The interest from CCITT arises from the requirements to internationally standardise text/graphic and other communications services that could be offered by CCITT member bodies, eg Facsimile, Teletex, Videotex, Message Handling, Electronic Mail etc. These kinds of services are applications and thus, necessarily, require elements of all the layers of the OSI model. The distinction between pure data communications and pure data processing has become less clear. The concepts involved in advanced office automation and the electronic office require both raw communications and processing to be part of the complete 'service' package.

CCITT COM VIII has published Recommendation S.70, a "Network-Independent Basic Transport Service for Teletex". S.70 is compatible with a defined subset of the ECMA - 72 standard (Class 0).

Both ISO and CCITT COM VII are studying the transport layer in the context of a wider range of usage than S.70, and see S.70 as a defined subset of the total capabilities. The amount of official liaison is greater than ever before and the personal representation in both CCITT and ISO committees has increased. There is every indication that a single standard will be produced, even though it would appear as separate publications from ISO and CCITT.

The value of the work of ECMA has been acknowledged and there is also a strong desire that as much as possible of the ECMA standard should be included in the CCITT/ISO standard.

3. ARCHITECTURAL ASPECTS

The ISO Basic Reference Model (1) for Open Systems Interconnection defines 7 Layers, see Figure 1. Important architectural relationships have been defined between the Transport Layer and the Network Layer, and Transport Layer and Session Layer.

The Transport Layer is the highest layer with any responsibility for the transportation of data. Thus the Transport Layer relieves the Session Layer entities from any concern with the means of transportation of data between them.

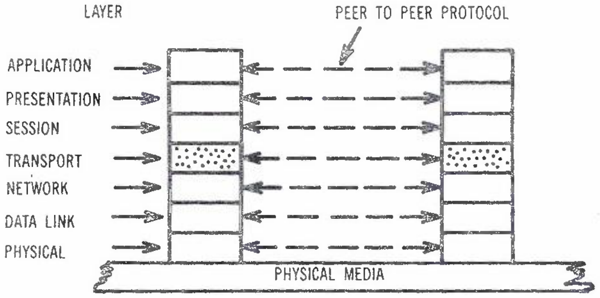

Figure 1. The ISO Basic Reference Model.

The Transport Layer is OSI End-System oriented. Thus Transport Protocols operate only between OSI End-Systems. Any relay functions or service enhancement protocols used to support the Network Service between the OSI End-Systems are operating below the End-Systems' Transport Layer (see Figure 2).

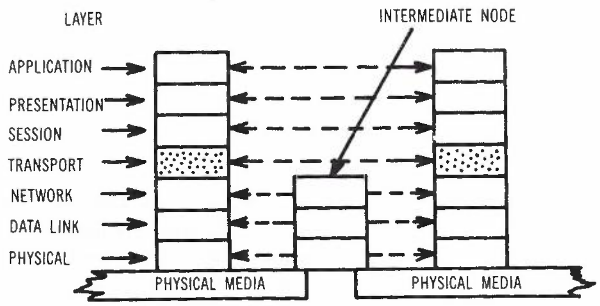

Figure 2. Model Showing that intermediate nodes operate below the Transport Layer.

The service of a layer, in the OSI context, is the set of capabilities which it offers to the user in the next higher layer. The service provided to the next higher layer is built upon the service provided from the lower layer, by the addition of appropriate functions. The functional entities themselves communicate by means of the peer-to-peer protocol. This concept is illustrated in Figure 3.

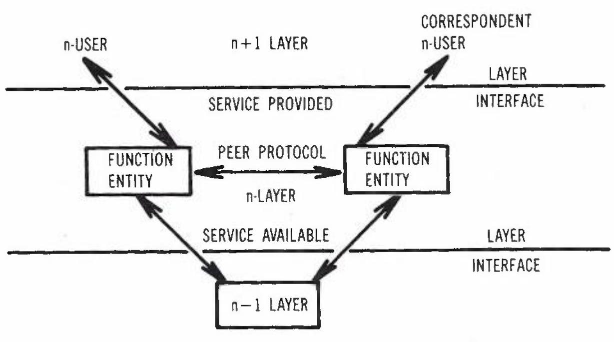

Figure 3. Layer Concepts

4. OBJECTIVES OF TRANSPORT LAYER

The primary objective of the Transport Layer is to provide to the Session Layer, data transportation at a required quality of service in an optimum manner. The Transport Layer thus 'bridges' the quality of service 'gap' between that required by the Session Layer and that offered by the Network Layer.

The quality of service requirements is expressed in terms of parameters requested by the Session Layer, eg throughput, transit delay, residual error rate, establishment delay, resilience, cost, security, priority etc.

The Transport Layer must provide all the functions to meet the quality of service requirements, and the necessary supporting protocols.

For example, if the throughput requested were in excess of the network access rate it might be necessary to establish more than one Network Connection, and a protocol for line-sharing would be necessary. Conversely one Network Connection might be able to support more than one Transport Connection, in which case a protocol for multiplexing would be necessary.

Extra capabilities for Error Detection and Correction might be necessary.

It should also be clear by now that the Transport Layer has to know the quality of service of the Network Connection before it can decide which function will have to be invoked over that Network Connection.

5. TRANSPORT SERVICE

The interaction between the user of the n layer and the provider of the n layer is described by a set of named service primitives. A named service primitive has one or more related parameters and related service primitive events. This method of service definition is accepted by both CCITT and ISO.

Groups of related primitives have similar names and are qualified to indicate their procedural role, eg user generated Requests and Responses, provider generated Indications and Confirmations.

Permissable sequences of primitives are indicated by time sequence diagrams (see Figure 4.)

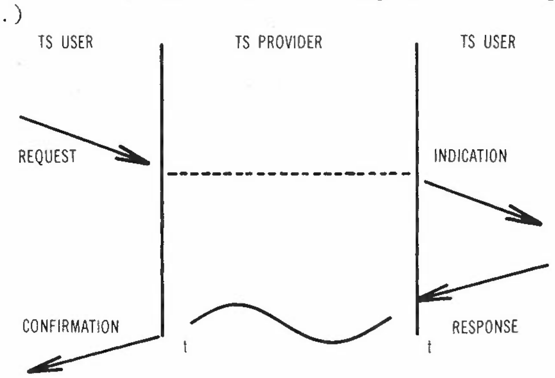

Figure 4. Time Sequence Diagrams

Necessary sequence relations between the 2 service access points are emphasised by a dotted arrow between the time lines.

Cases where no particular sequence is defined between the service access points are emphasised by a Tilde (/) between the time lines.

5.1 Service Primitives

The service primitives shown in Table 1 have been defined.

Some example sequences are shown in Figures 5a and 5b.

TABLE 1 - SERVICE PRIMITIVES

Primitive	Parameters
T-CONNECT request	(to transport address, from transport address, options, quality of service, TS-user data)
T-CONNECT indication	(to transport address, from transport address, options, quality of service, TS-user data)
T-CONNECT response	(responding address, options, quality of service, TS-user data)
T-CONNECT confirm	(responding address, options, quality of service, TS-user data)
T-DISCONNECT request	(TS-user data)
T-DISCONNECT indication	(Disconnect reason, TS-user data)
T-DATA request	(TS-user data)
T-DATA indication	(TS-user data)
T-EXPEDITED DATA request	(TS-user data)
T-EXPEDITED DATA indication	(TS-user data)

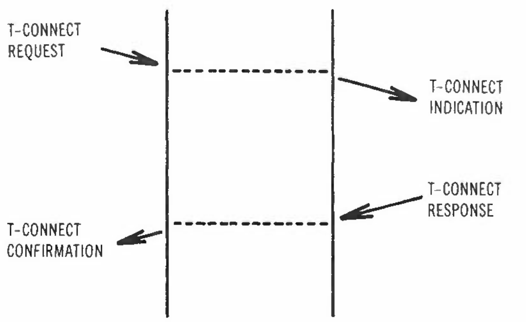

Figure 5a. Successful TC - Establishment

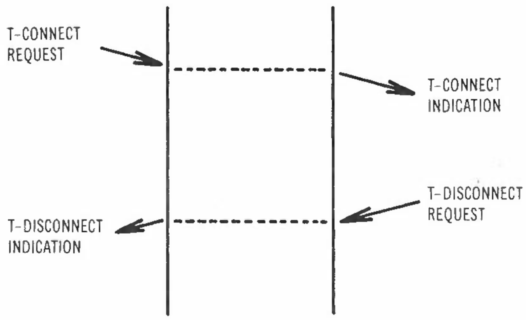

Figure 5b. Rejection of TC - Establishment Request by TS - User

6. TRANSPORT LAYER FUNCTIONS

The Transport Layer has to invoke functions in accordance with a set of parameters tailored to suit the application, over a wide range of Network Service qualities. The number and variety of functions is probably greater in the case of the Transport Layer than for most of the other layers.

The protocol is the externally visible representation of the functionality of the Transport Layer. Since there may be many separate functions within the layer, every function has to be represented by a protocol element. However, the combinations of parameters and protocols that could result, could give rise to selection and negotiation problems. Conversely, a protocol which accommodates all functions irrespective of whether they are actually required, would result in inflexibility and inefficiency.

These considerations led to the concept of classes of protocol in ECMA - 72. There has been considerable difficulty in agreeing the grouping of the functions and agreeing the nature of a group structure. The original ECMA proposals were based on a strict hierarchical set of protocol classes, where protocol Class N was always a sub-set of Class N+1. The consequence of this is that if a particular function only exists in, say, Class 3, all the functions of Classes 0, 1, 2 are included irrespective of whether they are required.

Both the current studies in ISO and CCITT are based on a variation of the ECMA proposals. There has been a relaxation in the requirement for a strict hierarchy of protocol classes and acceptance of the use of options within classes to overcome the disadvantages described above.

7. TRANSPORT LAYER PROTOCOLS (4)

7.1 Protocol Classes

Both CCITT and ISO have agreed on the following 5 protocol classes:-

Class 0 - Simple Class

Class 1 - Basic Error Recovery Class

Class 2 - Multiplexing Class

Class 3 - Error Recovery and Multiplexing Class

Class 4 - Error Detection and Recovery Class

With the exception of Classes 0 and 1 transport connections of different class may be multiplexed together onto the same network connection.

Classes and options within classes are negotiated during the connection establishment phase.

Options define additional functions which may be associated within a class.

The choice of class will be made by the transport entities according to:-

the users requirement expressed via T-CONNECT Request T-CONNECT Response service primitives;

the quality of the available Network Service;

the user required service versus cost ratio acceptable to the transport user.

The classes are intended to cater for, among other things, the following types of Network Connection:-

<u>Type A</u> Network connections with acceptable residual error rate (for example not signalled by "clear" or "reset") and acceptable rate of signalling failures.

<u>Type B</u> Network connections with acceptable residual error rate (for example not signalled by "clear" or "reset") but unacceptable rate of signalling failures.

<u>Type C</u> Network connections with residual error rate not acceptable to the TS user.

It should be noted that Types A, B, and C have no absolute figures, and that what may be Type A for a given application may be Type B to another.

7.2 Common Elements

The Basic protocol unit is the Transport Protocol Data Unit (TPDU).

TPDUs, in general, are classified either as Data TPDUs or Control TPDUs. Unless there is a means of indicating the length of data in data TPDUs, concatenation of Control and Data TPDUs can only be achieved by placing Control TPDUs in front of a Data TPDU in a concatenated set of TPDUs.

All classes use the T-Connect Request/Indication and T-Connect Response/Confirm. This protocol exchange provides for:-

Identification of calling and called session entities by use of reference numbers.

Negotiation of classes and options.

Negotiation of size of Data TPDU.

Connection Identification.

Exchange of parameters.

Exchange of user data.

Since the Transport Service Data Units are not constrained in size they have to be segmented into manageable protocol sizes. The integrity is maintained by an end of TSDU indicator carried in every TPDU. This permits TPDUs to be chained together to represent a complete TSDU.

7.3 Class 0 - Simple Class

This class has the minimum functionality of all the classes, and is fully compatible with CCITT Recommendation S.70 Teletex Terminals. This class is for use over Type A Network Connections.

Only functions for establishment, data transfer with segmenting, and error reporting are available.

There are no functions for multiplexing, disconnection, flow control, error recovery or expedited data transfer.

Furthermore no exchange of user data is permitted during connection establishment, and only address and TPDU size parameters are allowed.

Since there is no explicit disconnection procedure the life time of the Transport Connection is dependent upon, and the same as, the life time of the Network Connection.

For Class 0 the standard maximum Data TPDU length is 128 octets including the TPDU header.

7.4 Class 1 - Basic Error Recovery Class

The objective of this class is to provide recovery from network signalled errors (network disconnect or reset).

This class is intended for use over Type B Network Connections.

Class 1 provides Transport Connections with error recovery, expedited data transfer, disconnection, and flow control based on the underlying Network Service provided flow control.

Data may be exchanged during connection establishment.

No functions are provided for multiplexing.

It should be noted that the procedures for Class 1 have only recently been finalised. This Class 1 differs significantly from that defined by ECMA-72 and reflects a compromise agreement within ISO and CCITT.

7.5 Class 2 - Multiplexing Class

This class provides the capability of multiplexing several Transport Connections within a single Network Connection. This class has been designed for operation over Type A Network Connections.

The use of flow control within the protocol is an option of this class:-

Flow Control Option

This option can be used to reduce congestion, optimise response times and resource utilisation. This is required when the traffic is heavy and continuous and/or when there is a high degree of multiplexing taking place.

No Flow Control Option

This will allow multiplexing but with the absence of explicit flow control within the protocol. This can be useful for Transport Connections with non-critical response time requirements, or with infrequent short bursts of traffic with a predictable low total level of utilisation of the underlying Network Connection.

No functions are provided for error detection or error recovery. If the network resets or disconnects, the Transport Connection is terminated without an explicit end-to-end exchange and the TS-users are informed.

Class 2 provides the following functions in addition to those available in Class 0.

- Multiplexing
- Flow Control
- Exchange of user data during connection establishment
- Credit Mechanism (with flow control option)
- Expedited Data Transfer
- Explicit Disconnection

7.6 Class 3 - Error Recovery Class

The objective of this class is to provide Class 2 with the additional functions to permit recovery from network signalled errors (network disconnect or reset). This class is intended for use over Type B Network Connections.

7.7 Class 4 - Error Detection and Recovery Class

The objective of Class 4 is to detect lost TPDUs, mis-sequenced TPDUs and duplicated TPDUs and/or parts of TPDUs (control or data type).

Class 4 is designed for use over network connections considered to have an unacceptable residual error rate relative to high level requirements, ie a Type C connection.

The main differences from Class 3 are the addition of time-out mechanisms and resultant extra procedures, and a checksum mechanism.

7.8 General Structure of TPDUs

TPDUs are divided into 4 parts as shown in Figure 6. All TPDUs contain an integral number of octets.

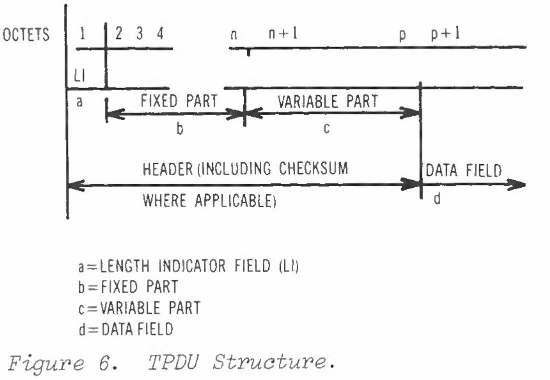

Figure 6. TPDU Structure.

8. CONCLUSIONS

A detailed description (5) has not been possible within the constraints of this paper.

Nevertheless, this account of the work should convince most readers that a great deal of progress has been made and that the availability of an international standard is not far off.

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BIOGRAPHY

Keith G. Knightson is Head of Standards and Protocols Group in the Digital Data Networks Division of British Telecom. He has been an active participant in CCITT in the development of the packet-switching Recommendations. He also is involved with Open System Interconnection Standards both in CCITT and ISO, and is currently the CCITT SG VII Special Rapporteur for the Transport Service, Transport Layer, and Network Service. He was actively involved with specification and implementation of BT's Packet Switched Service (PSS) and value-added services, and the UKs earlier Experimental Packet Switched Service (EPSS).

Keith holds both a B.Sc. and an M.Sc. in Computer Science, is a Chartered Engineer, and a Member of the Institute of Electronic and Radio Engineers.

Experience with Operating Packet Switching Public Data Networks

P. GUINAUDEAU

Many public packet switching networks are now in operation or planned for the near future in various countries throughout the world. The management of such networks has become an important activity for those companies and administrations involved.

This paper discusses some techniques used for operating packet switching networks, in particular in the following areas: control of faulty conditions in network equipments, maintenance of user connections, extensions of network hardware and software collection of billing and statistics records.... the use of testing equipment is also presented.

CCITT recent discussions on these issues are outlined.

1. ESTABLISHMENT AND CONTROL OF USER CONNECTIONS

One of the most significant elements in the recent development of Public Packet Switching Networks has been the X25 Recommendation by the CCITT, which defines the standard access of packet mode data terminal equipment to public packet switching networks.

More and more X25 equipment is now available in various countries. By the end of January 1982, on the TRANSPAC network, which is the national public packet switching network in France, there were about 5500 direct user connections, including more than 4200 X25 connections. Such an important percentage of X25 connections on the network can be considered as resulting mainly from:

- a large promotion of X25 among suppliers of data processing equipment,
- the decision made by TRANSPAC to provide only internationally standardized interfaces, and not to provide any customized protocols supported by large manufacturers,
- the availability of detailed technical specifications for the use of the network.

The next sections discuss such issues in more detail.

General User Information on the Network

Because of the new nature of public packet switching networks, it is important that users be informed as efficiently as possible on the specific aspects of the new packet switching techniques.

Documentation of the Procedures to Access Packet Switching Services

From experience, it appears very useful to provide users, and terminal equipment manufacturers, with an exhaustive description of the procedures applying to the packet switching network.

For example, such documentation is maintained by TRANSPAC (Specifications Techniques d'Utilisation du Reseau - STUR). It contains:

- detailed information on all mechanisms to access network service,
- guidelines for the operation of user equipment connected to the network.

The accurate maintenance of such technical documentation is made simpler if only a limited set of standard interfaces are supported on the network.

Seminars on Packet Switching Techniques

Various types of seminars can be of use in promoting packet switching techniques, and assist potential users in:

- designing a user application with sufficient knowledge of the technical and economic aspects of the possible solutions to their data transmission requirements:
- implementing any necessary adaptation for accessing the network,
- controlling one or several accesses to the network, or even a complete "network" of user equipment connected to the public packet switching network.

For example, TRANSPAC provides users with two types of seminars:

- one on the way to use TRANSPAC (3 days), which intends to give general information on TRANSPAC services so that a potential user can design a data transmission application through TRANSPAC,

- one on the technical aspects of the access to TRANSPAC (5 days), which is intended to explain user interface mechanisms (X25 and PAD) and specific operational aspects of TRANSPAC connections.

In the year 80-81, there were 110 days of such seminars, for a total of about 730 persons.

User Group

The establishment of a user group seems to be an appropriate way to promote user information about the network. It also assists the network supplier in final design of some network operation aspects. The information disseminated includes:

- an analysis of the problems encountered by users in connecting data processing equipment to the network,

- a promotion of new X25 products developed by computer and terminal manufacturers,

- the study of administrative issues related to the use of the network, contracts, lists of access parameters,....

In France, such a user group called GERPAC was created long before TRANSPAC was put into commercial operation, and actively participated in the network planning and development.

Certification of new X25 Subscriber Products

Today there is still some debate among packet switching experts on whether a new X25 subscriber product (i.e. a new X25 implementation within user data terminal equipment) should be tested or not by the network supplier before it can be fully introduced on an operational public packet switching network.

When such a certification is considered necessary, it is intended to guarantee appropriate protection of the network equipment against any possible malfunction of user equipment.

However it is also recognized that an operational X25 packet switching network needs to be protected anyway against user malfunctions. More automatic mechanisms are involved within the user equipment, which are more computer oriented than most of the user equipment attached to traditional telecommunications networks; this may cause more systematic difficulties in the network. Protection of the network needs to be seriously considered by the network supplier anyway. This can be done in particular by:

- exhaustive tests on the proper reaction of the network to any possible user malfunction, before connecting actual commercial users, with X25 simulation of user equipment,

- appropriate elements of tariff structure, intended to discourage some of those malfunctions (e.g. a fixed charge for any call attempt)...

If any new X25 implementation within data terminal equipment had to be certified by the network supplier before it could be accepted on the operational network:

- more technical assistance from the network supplier would certainly be required,

- additional delay would often result, before the new X25 product could actually be made available on the network.

Selection of Parameters for a new Subscriber Connection

When connecting a new subscriber to a telecommunications network, specific options or parameters have to be settled between the user involved and the network supplier.

On traditional networks, such as the existing telephone network, the subscriber interfaces follow simple standards in general, and it is generally simple to define options for those interfaces.

Today on a Packet Switched Public Data Network, more parameters have to be selected at subscription time. Registrations, cancellations, and modifications of those options or parameters have become an important part of the activity for the suppliers of such networks. It is certainly useful to consider the possible means to simplify such administrative activity. This can be done in particular:

- by avoiding too many different user interfaces on the network,

- by examining any simpler way to handle those interface parameters.

For example, the only access procedures supported by TRANSPAC are:

- the CCITT X25 access procedures, for packet mode data terminal equipment,

- the CCITT PAD procedures, for asynchronous data terminal equipment (see CCITT Recommendations X3, X28 and X29).

As a consequence, any subscriber wanting to connect to TRANSPAC using different procedures from the above needs an adaptor as shown in Figure 1.

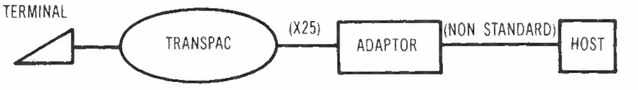

Figure 1. Example of X.25 Adaptation

Simpler ways to handle interface parameters may be studied by the CCITT in the future. In particular, the following methods can be envisaged:

- some parameters may be given fixed values.

- some other parameters may be negotiated at the interface (e.g. SABM/SABME fixes the frame level modulo).

- some other parameters may be negotiated through a kind of network management call, between user equipment and network equipment.

Such an issue may become even more important, in order to be able to offer adequate X25 access to packet switching networks via the switched telephone network.

<u>Maintenance of User Access</u>

Maintenance of user access requires careful attention by the network supplier. Within the network, it should in particular be possible to get a report for any event related to user access.

Since such a capability should not at the same time "congest" operators analysing messages generated by the network, it seems that:

- the network should be prepared to produce if necessary a large variety and detail of information about user access,

- at any time during normal network operation, the network operators should have the means to adjust the level of information provided on certain user accesses, using simple commands.

As an example, a flexible scheme for controlling such information about user access is indicated in Figure 2.

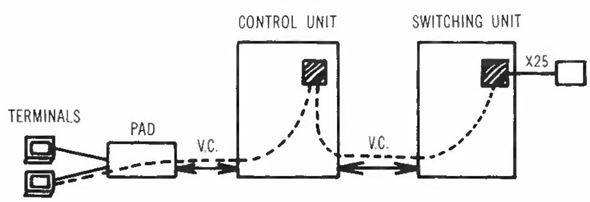

Figure 2. Example of Transfer of Information related to a User Access.

In such an example, information collected in the switching unit involved in the user access control is transmitted to a control unit on a virtual call. That information can be processed in the control unit before it is finally transmitted to a display terminal on another virtual call via a PAD. With this organisation of user access control, it is possible to access the control information from various places in the network, depending on the actions planned in general for user assistance, such as:

- detection of link failure,

- "on-line" assistance to debug a user procedure error.

2. NETWORK MANAGEMENT

<u>Control of Network Configuration</u>

Correct network control is essential to guarantee a reliable service through the network. Consequently it is very important to be able to detect and control any failure in an internal network component, mainly links and switching equipment.

Network operators need to be able to control the internal links between nodes. Among the mechanisms that can be offered to assist network operators and protect the network against internal link failure are:

- the immediate reporting of any problem detected on a link to network operators, with detailed diagnostics of the failure if possible,

- the systematic establishment of a connection between two nodes by using more than one physical circuit, using a "multiple line" procedure. Such a procedure, for which more details are given later in this document, avoids the flow of packets being blocked when a failure occurs on one physical circuit.

- sufficient flexibility in the network routing mechanisms, so that re-routing of traffic can be easily achieved in case of a complete link failure between two nodes.

Hardware redundancy, and switch-over mechanisms between network components, may also be designed in such a way that hardware failures have minimum impact on quality of service.

The growth of packet switching networks needs to be considered. As a result, specific attention is needed to allow many possible extensions of the network configuration, such as:

- extension of switching or connecting capacity of existing nodes,

- software extensions,

- insertion of new nodes,

- insertion of new links,

- change in the network topology and routing mechanisms, especially to take into account increased traffic,

- use of new generations of network equipment, ...

<u>Software Management</u>

Network software constantly needs to be modified or enhanced, in keeping with possible evolution in network operation, such as:

- additional facilities to be provided to the users,

- extension in an existing node (increase in the number of accesses, additional switching capacity,....),

- change in the network topology, which may cause the routing strategy to be modified,

- testing of particular network equipment by means of special test software temporarily loaded on that equipment,...

A modular software architecture is an important element which facilitates supervision of any piece of software within the network. With such architecture, it is possible to provide a mechanism for adding or modifying some pieces of network software without changing the basic parts of the system and without disturbing commercial operation.

It is convenient to manage network software from a Network Management Centre with the following facilities:

- systematic reports on the status of any piece of software in the network, gathered at that Network Management Centre,

- automatic down-line loading of pieces of software from that Network Management Centre.

In some cases, the report of a faulty condition detected by software in switching equipment may be related not to a software problem, but to a hardware problem. It is therefore important to keep software management functions closely associated with the monitoring of network hardware elements.

In order to limit as much as possible the failures that may be caused by software during normal operation, it is also important to perform some kinds of acceptance tests on any new piece of software introduced in the network. This can essentially be done using:

- spare and stand-by hardware elements in the network,

- appropriate testers, like X25 simulators or load testers on which more details are given later in this document.

Collection of Statistics and Billing Information

In public packet switching networks today, the processing of statistics and charging information needs to respond to specific requirements:

- Tariffs are based on new elements, in particular the volume of data transferred in the virtual call. Such an element of tariff does not exist in other networks like the telephone network; it takes into consideration the specific way resources are allocated for data transmission through a packet switching network, mainly at the time of actual data transmission.

- Also more detailed statistics at the beginning are important for the network supplier to make any appropriate plans for network extensions, essentially a time when users behaviour may still be difficult to foresee.

It is not simple to determine to what level of detail the network should generate such statistical and accounting information. For example, as far as the collection of charging information within the network is concerned, several possible levels may be envisaged:

:: either several billing records for each call, such as one at the call establishment, one at the call clearing, and intermediate periodical records if needed.

:: or a "ticket" for each call, gathering in only one record all charging and accounting information for that call, complete calling and called users addresses, exact time and duration of call, volume of data, special facilities required on the call,..

:: or global "counter" for each subscriber, with global traffic accounting elements for establishing a bill for that subscriber (e.g. on a monthly basis).

In most cases today, the solution consisting of one "ticket" per call appears to be satisfactory as long as the number of calls to be recorded does not become too large. However, global subscriber accounting may be considered as a cheaper solution within the network, if detailed information is not required by the users and by the network supplier; such a method is often used in telephone networks.

Also it is interesting to note that the CCITT is currently considering a mechanism to inform an X25 user equipment of the charge corresponding to a call; this information would be provided automatically at the call clearing time to the user charged for the call.

When the calling terminal is not directly connected to the network, and in the absence of reverse charging, the calling subscriber needs to be identified for charging purposes. A scheme is already defined for calling user identification in the case of asynchronous terminals accessing a packet switching network via the switched telephone network (Network User Identification - NUI). Another caller identification scheme is required for X25 terminals accessing a packet switching network via the telephone network, and is currently being studied by the CCITT.

3. INTERCONNECTIONS WITH OTHER NETWORKS

International Connections

More and more international connections are now being established between public packet switched data networks in the world, using the CCITT Recommendation X75 which defines the "Terminal and transit call control procedures and data transfer system on international circuits between Packet Switched Data Networks".

Although X75 was designed in close relation with X25, X75 covers specific aspects of the international inter-network operation : international format of addresses, transit network identification, detailed network diagnostics,...

In several countries today, the operation of international connections is handled in a piece of separate equipment, or transit node, connected to nodes supporting the national subscribers.

For example, an International Transit Node (NTI) was built in France, to connect TRANSPAC to various foreign packet switching networks. This transit node is connected as indicated in Fig. 3.

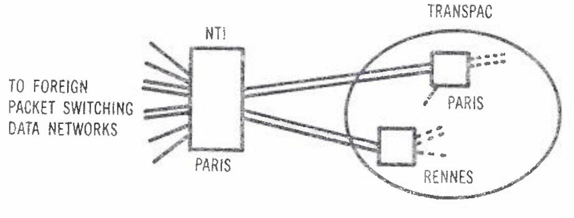

Figure 3. Connection of TRANSPAC to Foreign Networks via the NTI.

In order to offer a high reliability of data transfer, some of those connections are established through two circuits using different transmission paths; in this case a "multiline" procedure is used at level 2. The corresponding configuration is further explained by Fig. 4.

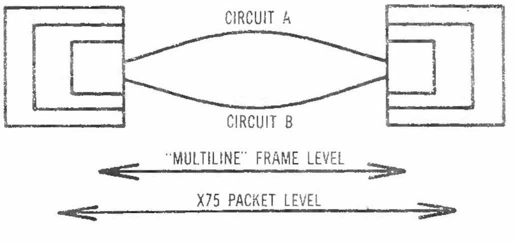

Figure 4. Connection with "Multiline" Procedure

The advantages of a "multiline" procedure is that traffic is dynamically split on the available circuits, and flow of data is not blocked by a failure on one circuit.

The CCITT recently standardized such a procedure, named "Multilink" procedure.

Connections with Packet-Switched Private Network Equipment

The technical aspects of connections between a public packet switching data network and private packet switching equipment are currently being studied by CCITT Study Group VII. Some experts in packet switching within this Study Group of CCITT have already confirmed that Recommendation X25 is generally applicable for such connections; several questions will still be examined: specific addressing and routing mechanisms, arrangements for closed user groups when required, signalling of an error condition initiated within the private network,...

One important aspect of such connections may be that two different types of networks have to be considered, and that sufficient distinction is needed on responsibilities taken by each network supplier in the provision of data transmission services.

Connections With Other Types of Networks

The studies of interworking with other networks is currently taking an important place in CCITT Study Group VII, particularly in view of the future Integrated Services Digital Network.

4. X25-ORIENTED TEST EQUIPMENT

Various kinds of X25-oriented test equipment are now available on packet switching networks:

:: Traffic Monitors for tracing the traffic transmitted on a link, in one or two directions : bit transfer, HDLC framing, CRC processing,.... Some of this equipment can analyse X25 headers and consequently offer an X25-oriented display of frames, packets,...They may also memorize a certain amount of traffic, display a particular element on the basis of simple selection criteria (e.g. value of the frame address octet, value of packet logical channel number,...). Fig. 5 indicates one way of connecting such a traffic monitor to an X25 interface, close to the Data Terminal Equipment.

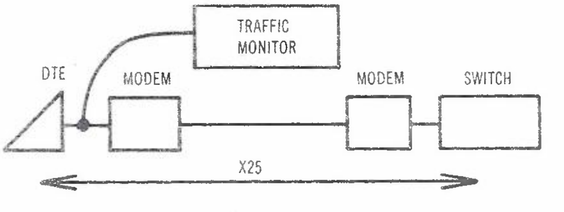

Figure 5. Example of Traffic Monitoring Configuration.

The TE 92 tester is one example of equipment capable of monitoring X25 (or X75) traffic, with X25-oriented display.

:: X25 simulators, which can simulate many normal and abnormal conditions of the X25 procedures, such as local X25 procedure errors caused by user equipment, incorrect call requests received from user equipment,... They may simulate a DTE connected to the network, as indicated in

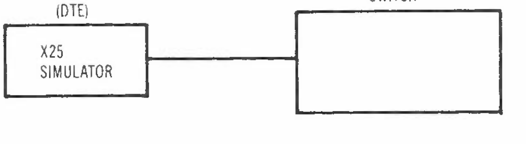

Figure 6. Example of X.25 Simulation on a Network.

Fig. 6; they may also simulate a packet switching node connected to user equipment, as indicated in Fig. 7.

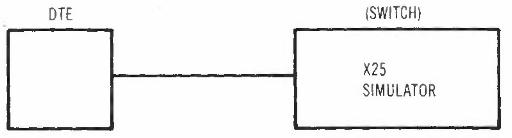

Figure 7. Example of X.25 Simulation on a User DTE.

As an example, the TE 92 tester can perform such X25 simulation, in particular with the execution of complete groups of tests (or "scenarios") using a special X25 simulation language called SITREX 25.

Also an "ESOPE" tester was designed in France for simulating an X25 DTE connected to TRANSPAC, and to test TRANSPAC reaction to any user procedure error.

Since X25 and X75 procedures are very similar, most X25-oriented test equipment can handle both X25 and X75 procedures (e.g. TE 92 or ESOPE).

:: Load Testers, for generating heavy traffic on a packet switching system. At the moment, such load testers often consist of spare switching machines with special software (spare switching node elements, stand-by machines). These allow the control of the reaction of packet switching equipment to heavy traffic conditions, and measure performance (number of packets per second, number of calls per second...). Figure 8 indicates one configuration for load testing with the load tester acting as a group of user Data Terminal Equipment.

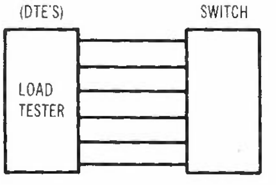

Figure 8. Example of Load Test Configuration

BIOGRAPHY

Paul Guinaudeau graduated from Ecole Polytechnique (1970) and Ecole Nationale Superieure des Telecommunications (1973). He has been working for the French PTT Research Laboratories (Centre Commun d'Etudes de Telecommunications et Television - CCETT, and Centre National d'Etudes de Telecommunications - CNET) since 1973, in the area of data transmission. He mainly worked on: technical studies on the French packet switching network called TRANSPAC (1973-1974), studies on TRANSPAC user accesses - specially CCITT work on X25 procedures (1975-1977), development of the International transit node (NTI) for TRANSPAC (1978-1981). Since 1974, he has been involved in the work of CCITT Study Group VII on data transmission, and is currently Special Rapporteur of this CCITT group on Questions related to interworking between different networks.

Issues in Standardization Arising in Implementation of Public Data Networks on a World-wide Basis

TOSHISADA OKABE

The role of the CCITT/ITU in the international telecommunication services, in particular data communication, is discussed.

In the early 1970's, the CCITT commenced the study of new public networks dedicated to data services in order to meet the stringent requirements for rapidly evolving data processing services that the existing telephone and telegraph networks might not be capable of satisfying in the future.

This paper briefly describes how the evolution of standards through the ITU (CCITT Recommendations) has been made for harmonious yet flexible developments of public data networks on a world-wide basis during the last decade.

1. STATUS OF CCITT RECOMMENDATIONS IN THE INTERNATIONAL TELECOMMUNICATIONS SERVICES

1.1 The International Telecommunication Convention (1), which is the basic instrument of the International Telecommunication Union (ITU), states that the purposes of the ITU are:

a. to maintain and extend international co-operation for the improvement and rational use of telecommunications of all kinds;

b. to promote the development of technical facilities and their most efficient operation with a view to improving the efficiency of telecommunications services, increasing their usefulness and making them, as far as possible, generally available to the public.

c. to harmonise the actions of nations in the attainment of those ends.

To this end, the ITU, as part of the wide area of its activity, undertakes studies, makes regulations, adopts resolutions, formulates recommendations and opinions, and collects information concerning telecommunication matters.

For data transmission as well as telegraphy and telephony the International Telegraph and Telephone Consultative Committee (CCITT), one of the four permanent organs of the ITU, is responsible for studying technical, operating and tariff questions and issuing recommendations on them.

1.2 The CCITT recommendations are not mandatory; however the Telegraph or Telephone Regulations (2) which lay down the general principles to be observed in the international telegraph or telephone service stipulate that in implementing the principles of the Regulations, administrations or recognised private operating agencies (RPOAs) should comply with the CCITT recommendations on any matters not covered by the Regulations. In fact they are normally accepted unanimously by the Member administrations and in certain countries they often serve as a guide for invitation to tender. Moreover, considerable interest is shown in these recommendations by a number of the international organisations that have related interests and activities and by manufacturers of telecommunication equipment.

1.3 Technical recommendations must have at least two functions:

- first, compatibility must be ensured between equipments, systems and procedures in different countries so that international communication is possible;

- second, the quality of international communication must be satisfactory, and this requires agreement on certain of the characteristics of national networks and international circuits.

These two functions are obviously indispensable at international level, but the activity of the CCITT should not necessarily be restricted to international telecommunication services. The best way of ensuring the required degree of compatibility and quality would be to standardise the equipments, systems and procedures used in all countries. If the CCITT recommendations also performed this function, industry too would benefit, but it has not always been considered feasible to draw up such specific agreements, since in certain cases this might infringe the sovereign right of each country to regulate its telecommunications.

1.4 The CCITT works through the medium of:

a. its Plenary Assembly, normally meeting every four years;

b. study groups set up by the Plenary Assembly to deal with questions to be examined;

c. a Director elected by a Plenary Assembly and a specialised secretariat which assists the Director.

1.5 As members of the CCITT the administrations of all Members of the ITU and any RPOAs with the approval of the Member which has recognised it may participate in all activities of the CCITT. Scientific or industrial organisations, which are engaged in the study of telecommunication problems or in the design or manufacture of equipment intended for telecommunication services, may participate in an advisory capacity in meetings of the CCITT study groups, provided that their participation has received the approval of the administrations of the countries concerned.

1.6 International organisations which co-ordinate their work with the ITU and which have related activities also take part in the work of the CCITT in an advisory capacity. In the study of data communication the CCITT attaches special importance to collaboration with other international organisations dealing with data processing, particularly the International Organisation for Standardisation (ISO) and the International Electrotechnical Commission (IEC). Such collaboration has to be organised in a manner that will avoid duplication of work and contradictory decisions.

Collaboration with these organisations in the work of international standards for data communication has been very fruitful to date and this should be continued further for the harmonious development of data communication services on a world-wide basis.

2. NEED FOR DEDICATED NETWORKS FOR DATA-TYPE SERVICES

2.1 A question on data transmission in the CCITT was first set-up at its 1st Plenary Assembly held in Geneva, December 1956.

During the initial decade the study of data transmission by the CCITT was inevitably concentrated on the use of the existing telephone and telegraph networks to provide facilities for this service.

The considerable interest and efforts devoted by the administrations, RPOAs and other organizations concerned in this study led to a large number of important Recommendations (V-series) which have fuelled the growth of computer-to-computer, terminal-to-computer, and terminal-to-terminal data communications to the present day.

2.2 Meanwhile data processing and the demand for data transmission were growing very rapidly all over the world. In about 1965 this fact drove the CCITT to consider whether the telecommunication administrations or RPOAs should continue to try to provide such facilities over the existing telephone and telegraph networks or whether a specialized data network or networks should be set up.

2.3 Big changes were also expected to come in transmission techniques. Digital systems were showing great promise for the future. The possibility was emerging of an integrated services network using time-division principles in the facilities for transmission, switching and control. Unfortunately, like all major changes, it would have to be introduced slowly and it was not possible to foresee when integrated services digital networks would be at least partially available internationally.

2.4 Based on these discussions the IVth Plenary Assembly in 1968 set up a new question which indicated the following three approaches for providing facilities for data transmission in the next 5, 10 or 20 years and ultimately, to be sought immediately:

1. the use of telegraph and telephone-type switched networks for combined operation with data services;

2. the characteristics of a separate switched network for data-type services;

3. the use for data of a future network for a general telecommunication service (data, telephone, telegraph, etc.) employing time-division techniques on an integrated basis for transmission, switching and control.

The study of the first and third points were entrusted to Special Study Group A (now Study Group XVII) and D (now Study Group XVIII) respectively as a continuation or extension of their terms of reference, and a special working party on new data networks (GM/NRD) was created for study of the second point.

2.5 In commencing the study of this entirely new subject, GM/NRD first drew up a full study programme that covered all possible aspects of public data networks in the context of its terms of reference. The intensive study based on this programme already yielded several basic recommendations for public data networks by the end of its first plenary period.

2.6 The importance and urgency for international standards for public data networks were further advocated at the Vth Plenary Assembly of the CCITT in 1972 and the status of a full study group was given to GM/NRD in order to expedite the progress of work in this field. Study Group VII on public data networks was thus set up in December 1972.

2.7 The initial work on public data networks produced a complete series of Recommendations (the X-series) on circuit-switched networks. The following work of Study Group VII in the mid and late-70s produced a complete and good series of Recommendations on packet-switched public data networks.

3. STATE OF CCITT RECOMMENDATIONS ON PUBLIC DATA NETWORKS (3)

In the past it can generally be said that communication networks have started nationally and then, at a later stage, the requirement for international connection has arisen. It is a considerable tribute to the work of the CCITT that such interconnection has been made possible. However, if the problem of international interconnection had been considered earlier in the national development of such networks the tasks of the CCITT in the past would have been very much easier.

The CCITT, keeping this point in mind, considered how public data networks should be established in order to offer to the user a wide range of data signalling rates with a minimum of restrictions, very short call set-up and clear-down times and a variety of new service facilities.

3.1 Data Service Requirements.

Recommendation X.1 covers a fairly wide range of international user classes of service which cater for three particular types of users' data terminal, namely for:

- terminals operating in the start-stop mode in classes 1 (300 bit/s) and 2 (50-200 bit/s).
- terminals operating in synchronous mode in classes 3 (600 bit/s), 4 (2400 bit/s), 5 (4800 bit/s), 6 (9600 bit/s), and 7 (48000 bit/s).
- terminals operating in the packet mode in classes 8 (2400 bit/s), 9 (4800 bit/s), 10 (9600 bit/s) and 11 (48000 bit/s).

In order to offer to the user a wider range of data signalling rates, consideration of the possible need for other data signalling rates such as 1200 bit/s and rates higher than 48 kbit/s will be given in the future study.

Rec. X.2 specifies the user facilities for each of the user classes of service indicated in Rec. X.1. A large number of user facilities for the various services are included in this Recommendation.

The provision of a number of user facilities in data communication services created a need to rationalise common aspects in order to achieve a coherent relationship between the relevant standards. Rec. X.87 has therefore been developed with a view to defining how an international user facility or network utility should be realized, where provided. The Recommendation covers for the time being only a few of these user facilities specified in Rec. X.2, i.e. closed user group, calling and called line identification, redirection of calls, connect when free, reverse charging, RPOA selection, network identification, etc. Inclusion of other facilities is under study.

The closed user group (CUG) facilities enable users to form groups with different combinations of restrictions for access from or to users having one or more of these facilities. They therefore create a need to standardize administrative procedures of international CUG numbers and the establishment of international CUG. Rec. X.180 has been developed in order to meet this requirement.

The provision of data communication services in various networks with data terminal equipments (DTEs) operating in different modes creates a need to produce standards to facilitate interworking between these DTEs. Consideration has been given to interworking in the following situation:

a. interworking between a DTE having an interface to a circuit switched data service and a DTE having an interface to a packet switched service,

b. interworking between a DTE having an interface to either a circuit switched or packet switched data service and:

   a DTE having an interface to a data service provided on a public switched telephone network;

   a DTE having an interface to the telex network.

For the case a) above a packet assembly/disassembly facility (PAD) which allows such interworking has been specified in Recommendations X.3, X.28 and X.29.

Various interworking requirements and their feasibility will be studied further from both the DTE/DCE interface and network signalling point of view.

Other important subjects for interworking between public data networks are an international numbering plan (Rec. X.121) and routing principles (Rec. X.110). The international numbering plan standardized in Rec. X.121 assigns a data network identification code (DNIC) to each public data network as shown in Fig. 1.

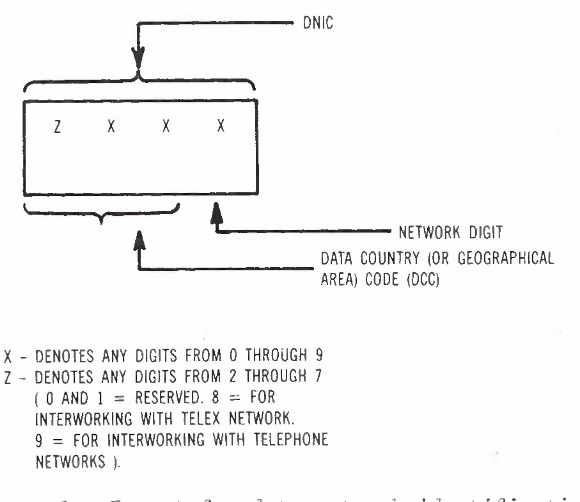

Figure 1. Format for data network identification codes (DNIC).

186 DCCs are currently listed in Rec. X.121. The member countries of the ITU not mentioned in this list who wish to take part in the international data service or those Members who require an additional DCC should ask the CCITT for the assignment of an available 3-digit DCC.

Rec. X.110 sets forth primary guide lines of the routing to be applied to international interworking among the same types of switched public data networks with a view to optimizing the quality of service and efficiency of operation.

The provision of call progress signals which inform the caller about the progress of the call is a useful network facility, in particular for establishing an international data call over public data networks in different countries. A large number of the call progress signals specified in Rec. X.96 would further broaden the usefulness of this network facility in informing the data caller of the circumstances which have prevented the connection being established to a called number.

One of the indispensable technical features for public data networks should be to ensure very short call set-up and clear-down times. Based on all the hypothetical reference connections defined in Rec. X.92 and other relevant Recommendations provisional objectives for call set-up and clear-down times in circuit switched public data networks have been specified in Rec. X.130, leaving the case of packet switched networks for further study.

The grade of service (GOS), as a measure of the traffic handling capability of the network, is a component of the overall quality of service experienced by the users, as well as a factor influencing the overall cost of the network. Provisional values of GOS to be observed as design objectives for international data communications over circuit switched public data networks have been specified in Rec. X.132. A draft Recommendation for the case of packet-switched networks has been carried over for further study.

3.2 DTE/DCE Interface

Rec. X.24 sets forth the definitions of interchange circuits for use in public data networks, implementing a minimum number of circuits for interfacing a digital network with new generation DTEs capable of more logic functions. For any type of practical equipment a selection will be made from the range of interchange circuits defined in this Recommendation. The electrical characteristics of these interchange circuits should comply with Rec. X.26 or X.27 of IC technology.

Rec. X.20 and X.21 define the physical characteristics and call-control procedures for a general purpose DTE/DCE interface for the user classes of service employing start-stop and synchronous transmission respectively.

Recommendation X.22 defines the interface between a DTE and a multiplex DCE, operating at 48 kbit/s and multiplexing a number of X.21 subscriber channels employing synchronous transmission, i.e. user classes 3 to 6.

Many DTEs are in use which are equipped with interfaces recommended for DCEs on telephone-type networks. For an interim period public data networks should also provide such interfaces in order to enable the connection of existing DTEs to these networks. For this purpose Rec. X.20bis for asynchronous duplex V-series modems and X.21bis for synchronous V-series modems have been issued.

In the course of the 1972-1976 plenary period the excellent technical and service features of the packet switched data service were suddenly highlighted and there was a strong indication that the implementation of this service in public data networks would be accelerated in many countries. To cope with this situation the CCITT recognized the urgent need for international standards for this service and developed Rec. X.25 for the DTE/DCE interface and others covering user classes, user facilities, logical channels and so on for this service. Based on the further study and experiences obtained through the implementation of packet-switched networks in various countries, these Recommendations have been thoroughly reviewed and improved in contents during the last plenary period.

3.3 Interworking of Networks

Rec. X.70 and X.71 define a decentralized terminal and transit control signalling system on international circuits between anisochronous (X.70) and synchronous (X.71) data networks respectively.

To meet the need for one common channel signalling system for use in international and national application in single service and multi-service digital networks, it was agreed within the CCITT to standardize a system of one part, the Message transfer part, that is common, and separate parts, the User parts, that are individual for different services and applications. During the last plenary period a common channel signalling system, known as CCITT Signalling System No.7 was developed by the telephone signalling Study Group in Series Q Recommendations. This system has been defined with a functional structure clearly separating:

- Message transfer part, common for all services and applications, and

- User parts for different services and applications, and in particular the Data user part for circuit switched data applications.

As a result of the study the following two Recommendations have been issued in the X-series:

- Recommendation X.60 which recommends the use of Signalling System No.7 including its Message transfer part and Data user part for circuit switched data applications.

- Recommendation X.61 which specifies the Data user part of the signalling system.

With the standardization of three different signalling systems as specified in Rec. X60/61, X.70 and X.71, the CCITT saw the need for providing a set of interworking procedures between any combination of these systems and developed Recommendation X.80, although it specifies for the time being only the case of interworking between X.60/61 and X.71.

As for the interworking of networks offering packet-switched service Rec. X.75 has been developed, keeping consistency with Rec. X.25.

Rec. X.50 and X.51 have been issued in order to meet the need to standardize the fundamental parameters of a multiplexing scheme for the interworking of data networks using different envelope structures (X.50) or between networks using the 10-bit envelope structure (X.51). During the last plenary period five new Recommendations in association with X.50 and X.51 (X.50 bis, X.51 bis, X.52, X.53 and X.54) have been developed. Rec. X.50 bis and X.51bis supplement X.50 and X.51 respectively, covering the case where the user data signalling rate is 48 kbit/s. Rec. X.52 specifies the method of encoding anisochronous signals into a synchronous user bearer specified in either X.50 or X.51 when DTEs operating in user classes of service 1 and 2 are connected to synchronous data networks. Rec. X.53 and X.54 specify the numbering (X.53) and allocation (X.54) of the tributary channels on 64 kbit/s international multiplex links conforming to Rec. X.50 and X.51.

3.4 Tariff Principles for Data Transmission on Public Data Networks

The advent of public data networks that provide a number of international user services and facilities necessitates the adoption of new tariff principles other than the classical ones based on the concept of duration and distance.

The following four Recommendations are currently issued on the subject:

D.10 General tariff principles for data transmission on public networks dedicated to this type of transmission.

D.11 Special tariff principles for packet switched public data transmission services by means of the virtual call facility.

D.12 Measurement unit for charging by volume in the international packet-switched data transmission service.

D.20 Special tariff principles for public international circuit-switched data transmission service by means of public data networks.

3.5 Series X Recommendations

Series X Recommendations on "Data communication networks" that came into force after the VIIth CCITT Plenary Assembly (November 1980) are as follows:
(Published in the CCITT Yellow Book, Volume VIII.2 and VIII.3):

Section 1 - Services and facilities

X.1 International user classes of service in public data networks

X.2 International user services and facilities in public data networks

X.3 Packet assembly/disassembly facility (PAD) in a public data network.

X.4 General structure of signals of international Alphabet No. 5 code for data transmission over public data networks

X.15 Definitions of terms concerning public data networks

Section 2 - Interfaces

X.20 Interface between data terminal equipment (DTE) and data circuit-terminating equipment (DCE) for start-stop transmission services on public data networks

X.29 Procedures for the exchange of control information and user data between a packet assembly/disassembly facility (PAD) and a packet mode DTE or another PAD

Section 3 - Transmission, Signalling and Switching

X.40 Standardization of frequency-shift modulated transmission systems for the provision of telegraph and data channels by frequency division of a group

X.50 Fundamental parameters of a multiplexing scheme for the international interface between synchronous data networks

X.50 bis Fundamental parameters of a 48-kbit/s user data signalling rate transmission scheme for the international interface between synchronous data networks

X.51 Fundamental parameters of a multiplexing scheme for the international interface between synchronous data networks using a 10-bit envelope structure

X.51 bis Fundamental parameters of a 48-kbit/s user data signalling rate transmission scheme for the international interface between synchronous data networks using a 10-bit envelope structure

X.52 Method of encoding anisochronous signals into a synchronous user bearer

X.53 Numbering of channels on international multiplex links at 64 kbit/s

X.54 Allocation of channels on international multiplex links at 64 kbit/s

X.60 Common channel signalling for circuit switched data applications.

X.61 Signalling System No.7 - Data user part

X.70 Terminal and transit control signalling system for start-stop services on international circuits between anisochronous data networks

X.71 Decentralized terminal and transit control signalling system on international circuits between synchronous data networks

X.75 Terminal and transit call control procedures and data transfer system on international circuits between packet-switched data networks

X.80 Interworking of interexchange signalling systems for circuit switched data services

X.87 Principles and procedures for realization of international user facilities and network utilities in public data networks

Section 4 - Network aspects

X.92 Hypothetical reference connections for public synchronous data networks

X.96 Call progress signals in public data networks

X.110 Routing principles for international public data services through switched public data networks of the same type

X.121 International numbering plan for public data networks

X.130 Provisional objectives for call set-up and clear-down times in public synchronous data networks circuit switching

X.132 Provisional objectives for grade of service in international data communications over circuit switched public data networks

Section 5 - Maintenance

X.150 DTE and DCE test loops for public data networks

Section 6 - Administrative arrangements

X.180 Administrative arrangements for international closed user groups (CUGs)

4. TELEMATIC SERVICES AND PUBLIC DATA NETWORKS (4) (5)

4.1 Telematic services

As described in Section 3 above, the CCITT X-series Recommendations today standardize a quite wide range of elements of public data networks.

These Recommendations have been developed primarily for establishment of separate switched networks dedicated to data-type services, i.e. for network services rather than for specific services in which the end-to-end compatibility of terminals should be ensured.

Recent and continuing developments in digital electronic technologies have made economically feasible the provision of new communication and information services by telecommunication (telematic services) other than voice and telex.

Current studies in the CCITT cover:

- Teletex,
- Interactive Videotex
- High-speed facsimile,
- Digital phototelegraphy,
- Telewriting, etc.

In view of the growing importance and urgency of these new services the CCITT undertook intensive and extensive studies in the late-70s and developed basic Recommendations for operational provisions, terminals and control procedures of Teletex, Vidotex and Facsimile services at the VIIth Plenary Assembly in 1980.

These are additional to the primary objective of the public data networks, i.e. data exchanges between computers, data processing installations and customer-selected terminals. Hence the new concepts of multimode networks designed to permit information exchange in numerous different forms.

4.2 Implementation of telematic services

From the beginning of the studies of the public data networks it has been the policy of the CCITT that these new networks should be designed with the view of offering to the user a wide range of flexibility which would cater to the development and application of present and future services and facilities. The network functions and facilities provided by the public data networks would therefore be best adapted for implementation of these new telematic services.

The question, however, is how to implement these services to meet the requirements of the users, taking full advantage of the PDN facilities yet ensuring the end-to-end compatibility of terminals.

From past experience we have learnt that success in introducing such new services depends on a whole series of factors. A factor of major importance is the establishment of the broadest possible user basis and this at once brings us up against the question of compatibility.

It is therefore important to standardize these new services to the level at which they will meet the requirements of the majority of potential users within the performance limits thus defined.

If so, how can the requirements of remaining users for additional facilities or innovation in the future be met?

This question of standardization versus innovation has been examined for some years in the CCITT. A possible solution to the problem would be to adopt the following three approaches:

1. CCITT recommended services For these services, the standard facilities defined in relevant Recommendations shall always be the standard for the recommended services. This requirement is necessary to ensure terminal-to-terminal compatibility for the services on a world-wide basis. Features of the recommended services are

detailed in these Recommendations, and should be guaranteed by the telecommunication administration or RPOAs.

2. CCITT Recognized options Where these are defined in CCITT Recommendations, they may be provided in addition to the international standard. The implementation and use of these recognized options is a national matter.

3. Non-standard facilities These facilities are not defined in CCITT Recommendations but are laid down by Administrations and/or individual manufacturers

The effects of the standard facilities recommended by the CCITT are not exclusively beneficial. Each standard implies a degree of restriction of the choice available to meet a particular requirement. Considering that requirement in isolation, a standardized solution may be less advantageous than some non-standard alternative.

The second and third approaches, however, could provide a solution which would meet these additional user requirements or innovation.

With this system how can we ensure trouble-free interworking of terminals? This is done by means of a Recommendation on end-to-end procedure, whereby the options available at the terminals are ascertained when the connection is set up. If both terminals have a common option, it is used in the ensuing communication; if not, use is made of the standard facilities which all terminals must have.

This three-tier system would afford maximum flexibility for the further development of facilities within the service without affecting overall compatibility for the basic service characteristics. For example, if a non-standard facility is used widely in a particular country or region, then it might be included in the catalogue of CCITT recognized options. In the same way, a CCITT recognized option might, as a result of universal use, be incorporated in the list of CCITT basic service characteristics.

In this respect the user classes of service (X.1), user services and facilities (X.2), call progress signals (X.96), and their categories specified therein, i.e. essential or additional, will have to be reviewed vis-a-vis each specific telematic service.

4.3 Reference Model for Open Systems Interconnection

Another important subject under study in the CCITT regarding the protocols for implementation of new services into a public data network is a layered reference model for open systems interconnection.

The purpose of this Model is (6):

- to specify a universally applicable logical structure encompassing the requirements both of public data networks and of their users;
- to act as a reference during the development of new communications services, including potential CCITT recommended services, and the definition of the corresponding procedures;
- to enable different users to communicate with each other by encouraging the compatible implementation of communication features;
- to enable the steady evolution of public data networks by allowing sufficient flexibility so that advancements in technology and the expanding requirements of users can be accommodated;
- to allow comparison of a proposed new user requirement with the services for existing user requirements, thus allowing the new requirements to be satisfied in a manner compatible with existing CCITT recommended services.

The general principles of the layered model are currently being studied by Study Group VII in the context of public data networks in close collaboration and liaison with other bodies studying reference models in order to ensure the widest possible applicability of the resulting Recommendations. Meanwhile Recommendation S.70 which defines the network-independent basic transport service applicable to Teletex terminals connected to the different types of network (i.e. circuit-switched public data networks, packet-switched public data networks and public switched telephone networks) has been developed by Study Group VIII.

Other speakers will tell you much more about this subject.

5. CONCLUSION

Issues in standardization arising in implementation of public data networks have been briefly discussed in this paper.

In parallel with the current study of data transmission services over the PSTN and PDNs, the CCITT is actively engaging in the study of various aspects of the Integrated Services Digital Network (ISDN) which would ultimately carry all the telecommunication services. The migration of data transmission services to the ISDN is therefore an important subject to be studied in the future plenary periods.

During the certain transit period, there may exist different types of network (PSTN, PDNs and ISDN) for providing data and text communication services in various countries.

This will entail the complex and difficult questions of how efficient international interworking of these networks can be ensured. The CCITT will make further efforts in collaboration with other international organizations in order to accomplish this important task.

6. REFERENCES

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2. Telegraph Regulations and Telephone Regulations, Geneva 1973.

3. CCITT VIIth Plenary Assembly, Yellow Book, Volume VIII.2 and VIII.3, Series-X Recommendations: Data communication networks, November 1980

4. W.T. Jones : "Standards for telecommunication : The future ..... Role of CCITT", Telecommunication Journal, Vol. 46, pages 730-736, December 1979.

5. E. Hummel : "Standardization and innovation - Conflicting or complementary concepts?", Computer Networks, Volume 5, 1981, pages 318-320.

6. Proposed draft Recommendation, "Reference model for public data network applications", CCITT COM VII-No. R6, Kyoto April/May 1981.

BIOGRAPHY

Toshisada Okabe is a Counsellor of the International Telegraph and Telephone Consultative Committee, International Telecommunication Union in Geneva, Switzerland. He joined the CCITT/ITU Secretariat from the Nippon Telegraph and Telephone Public Corporation (NTT), Japan in 1962 and is currently responsible for CCITT Study Groups VII (Data Communication Networks), and XVII (Data Communication Over The Telephone Network).

Mr Okabe graduated from the Faculty of Telecom. Engineering, National Higher Institute of Communications (1949) and the Faculty of Literature, Aoyama Gakuin University (1954) in Japan. He also studied at Tokyo University Electrical Engineering (1954-1955) taking the sabbatical leave from the NTT.

Contribution of Formal Description Techniques to the Specification of International Data Communications Standards

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Standardised data communication procedures facilitate the economical exchange of information between computer systems interconnected via data networks. These procedures (or protocols) are necessarily complex to support a variety of applications with a wide range of network characteristics. As protocols are developed, specifications must be provided for many purposes. Initial descriptions provide a central reference for co-operation among designers of different parts of a system. The design should be checked for logical correctness and conformance to requirements before adoption as a standard. Standard specifications published in CCITT Recommendations have to be clearly and unambiguously understood by a wide audience concerned with the development of data communications equipment. Different implementations may need checking for compliance with the specification.

Many lessons have been learnt in the development of standard procedures for public data networks (e.g CCITT Recommendations X.21 and X.25). These standards are specified using informal techniques (e.g. narrative text) which can lead to ambiguous interpretation, and consequently, incompatible or inefficient implementations. The CCITT, through Question 39/VII, is studying the development of structured and formal techniques for more effective design and specification of future data communication standards. This presentation reviews the background of the work, introduces the concepts involved and reports on the current status.

1. INTRODUCTION

Study Group VII of the CCITT has produced Recommendations for:

- The connection of Data Terminal Equipment (e.g. terminals and computer systems) to public data networks (e.g. X.21, X.25), and,
- the international interconnection of public data networks (e.g. X.75).

These standards define the procedures for establishing connections and transferring data using the network. New standards governing the higher levels of communication between end computer systems are also required (e.g. Transport layer). The "Reference Model" and "Formal Description Techniques" are under study as tools which will provide a structured and formal basis for the development of these new data communications standards. Study Group VII is co-operating with the International Organization for Standardization (ISO) to ensure compatibility with the earlier work by ISO on these topics.

2. ARCHITECTURAL PRINCIPLES

A layered "Reference Model" of data networks is being developed as a basis for standardization activities (ie. through CCITT Question 27/VII). Question 39/VII is concerned with the study of formal techniques for specification of the data communication procedures developed within the framework of the Reference Model. For the purpose of Question 39/VII, four levels of abstraction are envisaged:

- Architecture description of the Reference Model which views the operation of a network of interconnected computer systems as a succession of layers, each of which provides a particular service (or set of functions) to the layer above.
- Layer description in terms of a Service Specification which defines the services provided by a particular layer to the users in the layer above.
- The operation of each layer in terms of its Protocol Specification which defines the peer-to-peer interactions necessary to perform the layer service.
- Implementation which is the system dependent transformation of the protocol specification into hardware and/or software.

2.1 Architecture of the Reference Model. The Reference Model defines a seven layer architecture and designates services to each layer. An essential principle is the "independence of layers", i.e. each layer is represented as a "black box" and the Reference Model does not define how each layer operates or provides its service. The operation of each layer is covered by a separate set of standards defining the protocol(s) used within the layer. The black box approach allows changes due to technological evolution or improvements in the protocol of a particular layer without requiring modification of adjacent layers.

2.2 Service Specification. The service specification should be the first step in the design of a layer. The total layer being specified, and all the layers below, are represented as a "black box". It is referred to as the service provider (Figure 1) and is

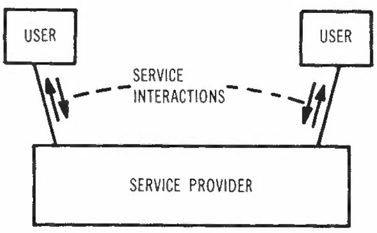

Figure 1. Model for Service Specifications.

described by the allowable sequences of input and output interactions between the service provider and the service users. A service specification requires:

. An abstract definition of the allowed interactions between the service user and service provider, and the associated data parameters.

. Local rules governing the allowed sequences of interactions between each user and the service provider.

. The end-to-end relationships of interactions exchanged between users via the provider.

. The specification of the quality of service in terms of performance parameters.

2.3 Protocol Specification. In a practical network, the service provider is distributed because of the physical separation of the users. This is achieved by:

. peer protocol entities within each user's computer system, and,

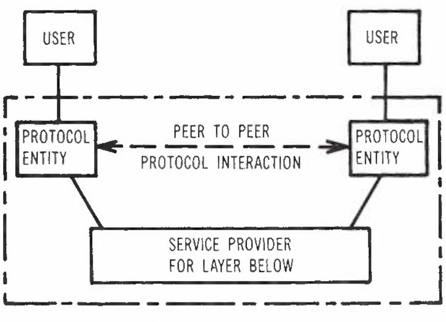

Figure 2. Model of Internal Structure of Service Provider for Protocol Specification.

. the service provider representing the layers below.

Figure 2 shows a model of the internal structure of a service provider which illustrates the relationship with the protocol entities. It follows that the protocol specification defines the allowed interactions between the entities comprising the service provider. More formally, it defines the mapping of service interactions between the user and the protocol entities, into peer-to-peer protocol interactions which are transferred by the layer below. A definition of the corresponding service interactions with the layer below is also required.

2.4 Implementations. The formal description techniques should facilitate the development of the required physical systems to give efficient and satisfactory standards of performance, without prejudice to the method of implementation. Automated implementation of protocols is a future possibility, although this is outside the scope of Question 39/VII.

3. FORMAL DESCRIPTION TECHNIQUES

Formal description techniques are required to unambiguously represent services and protocol specifications by increasing the degree of readability and comprehension. Accuracy and formality are other factors essential for design verification purposes and for testing of implementations against specifications. Automated verification, implementation and testing are also desirable because of the complexity of data communications procedures. This implies that specifications should include a machine readable version.

Study of formal description techniques has been conducted in a number of research centres (1) since the mid - 1970's. The techniques developed can be generally divided into two categories

. Temporal logic

. State machine model.

Temporal logic is an extension of classical modal logic used for defining the semantics of computer programs. Claimed advantages of the technique are:

. Maximum degree of abstraction resulting in implementation independence.

. Ease of automated verification using program proving techniques.

Additional research is required, however, before concrete results and a notation will be available.

The state machine approach is well known and is easily implemented. The system to be specified is modelled as a set of interconnected finite state machines which are introduced as a tool for clear and unambiguous presentation. Both state transition diagrams and program language notations may be used for the specification of finite state machines. Informal state transition diagrams have already been used in Recommendations X.21, X.25 and X.75. Because of the urgent need for formal description techniques, it has been agreed to concentrate on the state machine approach for the present study period.

The current work on Question 39/VII is concerned with the selection of a formal language for specification of services and protocols in terms of a state machine model. It has been agreed that specifications should contain both a graphical representation for the

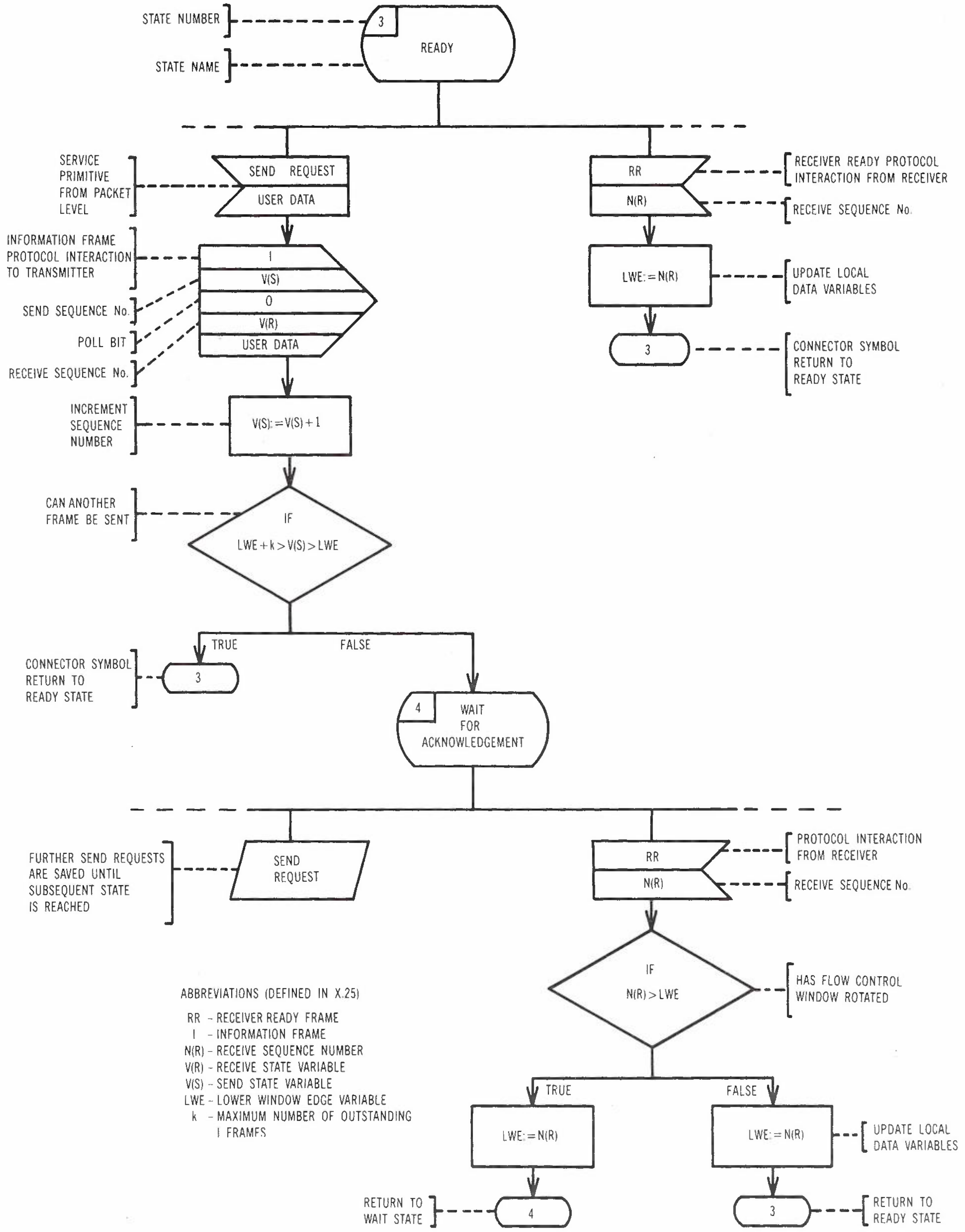

Figure 5. Simplified Extract from SDL Diagram for LAPB Protocol Block.

benefit of human readers and a high-level program language version for both human and machine interpretation.

The terms of reference for Question 39/VII were to study the suitability of the existing CCITT Specification and Description Language (SDL) (which was standardized by Study Group XI for use in telephone systems) and the desirability of other languages. There are two versions of SDL viz: a graphical form (SDL-GR) which is defined in Recommendations Z.101 to Z.104, and a draft proposal for a program-like form (SDL-PR). It has been agreed that SDL-GR should be the basis of the graphical form of specification for data communications, with perhaps some extensions. Two proposals for a program-language version were studied at the recent Melbourne meeting, March 1982, i.e:

- Extension of SDL-PR.
- Extension of PASCAL as proposed by ISO/TC97/SC16/WG1 ad-hoc group on formal description techniques, to incorporate state machine concepts.

There is significant similarity between the two proposals even though further development is required. The Melbourne meeting attempted to set the basis for the future development of a program-like formal description technique.

These specification languages are based on concepts similar to those of classical state transition diagrams. In the existing Recommendations, such as X.25, the protocol specification takes the form of an informal state diagram supplemented by a natural language description of the states and transitions. The formal languages combine state diagrams with a definition of the processing actions required in the transitions (2). Hence, all state information and processing actions relevant to the protocol or services may be explicitly defined on the diagrams and program-like equivalents, with the objective of presenting unambiguous specifications. In addition, a number of techniques are available for partitioning a complex specification into a number of smaller, more manageable modules to provide well structured representations.

4. EXAMPLE OF APPLICATION TO X.25

To illustrate the application of formal description techniques to data communications, Figure 5 presents a simplified extract from a contribution (3,4) to the Question 39/VII meeting in Melbourne. The example describes part of the data transfer procedures for the link level protocol (i.e. LAPB) of Recommendation X.25.

Recommendation X.25 is described in three hierarchical layers or levels, viz; physical, link and packet. The physical level provides full-duplex synchronous data transmission while the link level formats the data into frames and uses cyclic redundancy codes to detect errors in the data stream transmitted by the physical level. Error recovery is achieved by retransmission of frames.

In the example, the link level is further partitioned into three sub-blocks as shown in Figure 3 and described below:

<u>LAPB Protocol</u>. This block interacts with the packet level and governs link establishment, data transfer and disconnection by exchanging frames with the peer protocol entity.

<u>Receiver</u>. This block receives a bit stream from the physical level. The bit stream is examined, flags are identified, bit stuffing is reversed and frames are identified.

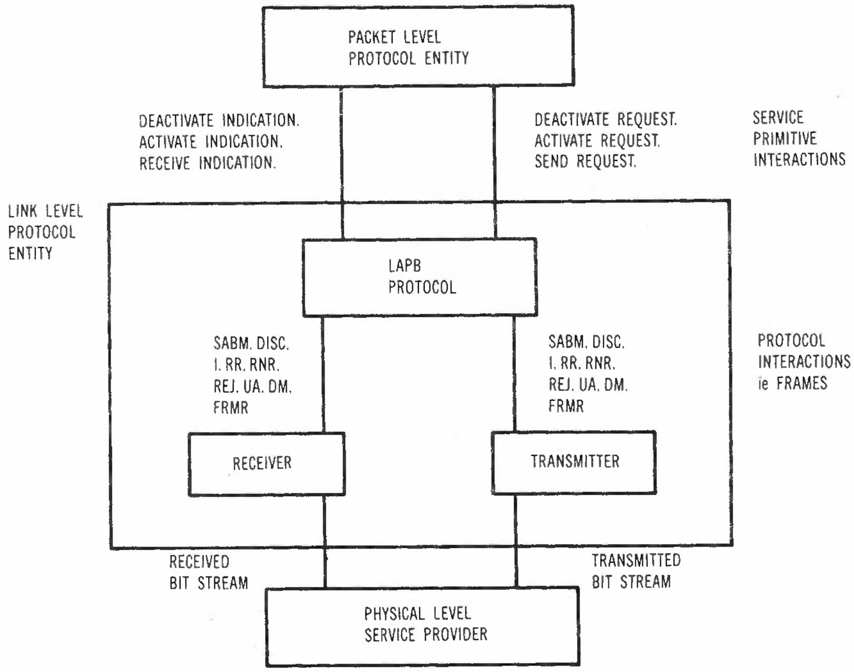

Figure 3. Functional Block Interaction Diagram for LAPB Protocol Example.

Transmitter. The transmitter accepts protocol interactions from the LAPB protocol block to be sent as frames to the peer. Flags, frame check sequency and bit stuffing are incorporated in the bit stream transmitted via the physical level.

The contribution to Question 39/VII described the behaviour of the LAPB protocol block in terms of ten states. The extract in Figure 5 shows selected transitions from two states concerned with the sending of Information Frames to, and waiting for acknowledgement from, the peer protocol entity. Each Information frame is sequentially numbered by a Send Sequence number. Reception of frames is acknowledged by the peer protocol entity by a Receive Sequence number, N(R), conveyed in Receiver Ready frames and other frames. The maximum number of frames which may be transmitted without acknowledgement is determined by the parameter "k". Certain LAPB procedures such as operation of time supervision and the poll/final bit are omitted for simplicity.

The description of these procedures in Figure 5 is based on the standard symbols and rules of SDL. Figure 4 illustrates the major symbols and the references (5,6,7,8,9) give comprehensive explanations. The notation used inside the symbols to represent manipulation of data variables needs to be formalised. Other enhancements to SDL are also under study. The program-like version of Figure 5 has not been prepared.

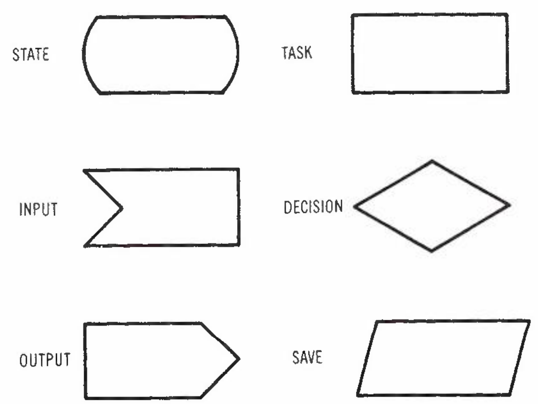

Figure 4. The Basic Set of SDL Symbols (Ref.2). (For simplicity, the differentiation between 'internal' and 'external' input and output symbols has been omitted).

The service and protocol interactions between blocks which are identified in Fig. 3 are represented as signals in the SDL description. Signal reception and sending are represented by input and output symbols in Fig. 5. (Asynchronous communication is assumed i.e. signals may be buffered between blocks). A block may be either in a state i.e. processing is suspended awaiting a new input signal, or executing a transition. Decision, task and output symbols in the transitions between states define all processing actions relevant to the protocol.

5. CONCLUSIONS

If the results from the study of Question 39/VII are accepted by Study Group VII, future Recommendations for data communications procedures will contain, in addition to a narrative description, a formal state transition diagram based on the special symbols and rules of SDL and a program language equivalent which could form the basis for automated implementation and system testing.

The formal languages should also prove of value to equipment designers and implementors for system documentation. This will assist Administrations, equipment manufacturers and users in providing compatible equipment for data networks.

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Acknowledgement

The example of the application of SDL to X.25 is based on a paper by Mr G. Wheeler and his assistance is gratefully acknowledged.

BIOGRAPHY

Gary Dickson received the B.E. (Honours) and M.Eng.Sc. degrees in Electrical Engineering from the University of Queensland, Brisbane, in 1975 and 1977 respectively. After working on telephone exchange installations, he joined the Telecom Research Laboratories in 1977 where he has worked on the formal specification of data protocols and the implementation of an X.25 interface on a mini-computer system.

In 1981, he was appointed as a CCITT Special Rapporteur of Study Group VII to co-ordinate study of formal description techniques. He is also the Chairman of the Technical User Group for the Australian public packet switched network, AUSTPAC.

CCITT Message Handling Facilities

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CCITT Study Group VII (Data Communication Networks) Working Party 5 (Network Aspects) is responsible for defining the services and protocols for store and forward message services; the CCITT term for these message services is Message Handling Facilities.

Message Handling Facilities provide capabilities for an originator to prepare a message and have it transferred to one or more named recipients. On receipt of a message, Message Handling Facilities provide capabilities for the recipient to examine and operate on the message.

In this presentation, the speaker will present the latest material on Message Handling Facilities. The speaker will discuss the layered model developed for Message Handling Facilities and explicate the services provided by each component of the model. In addition, the protocol structure of Message Handling Facilities will be presented and the purpose of each protocol described in the model will be discussed.

1. INTRODUCTION

CCITT Study Group VII (Data Communication Networks) Working Party 5 (Network Aspects) is responsible for defining the services and protocols for store and forward message services; the CCITT term for these message services is Message Handling Facilities.

Message Handling Facilities provide capabilities for an originator to prepare a message and have it transferred to one or more named recipients. On receipt of a message, Message Handling Facilities provide capabilities for the recipient to examine and operate on the message.

Functionally, Message Handling Facilities are provided by the Message Service; all services directly accessible to the users of Message Handling Facilities including preparation, transfer and presentation of meaningful information are provided by the Message Service.

In the sections that follow the logical structure of Message Handling Facilities is explicated in detail.

2. THE MESSAGE SERVICE

As mentioned in the introduction, the Message Service provides all services directly accessible to the users of Message Handling Facilities; included among these are preparation, transfer, and presentation of information meaningful to the users.

Logically, the Message Service consists of one or more Message Transfer Agents, collectively referred to as the Message Transfer Service, responsible for the storing and forwarding of messages between source and destination, and two or more User Agents (See Figure 1).

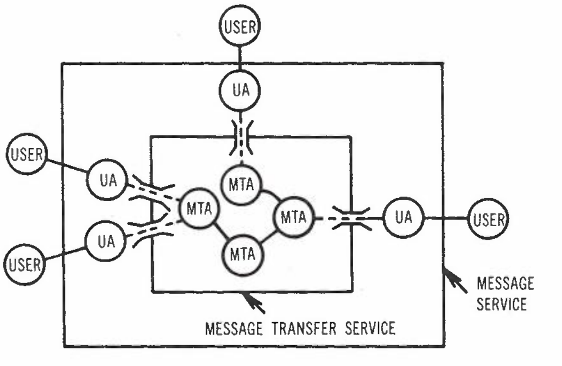

Figure 1. Functional Systems and Components.

Thus, the services* provided to users of the Message Service are the <u>resultant</u> of the services provided by the Message Transfer Service and the User Agents.

2.1 <u>The Message Transfer Service</u>. The Message Transfer Service provides the means necessary for co-operating User Agents to manage their exchange of messages. Two basic interactions between the User Agents and the Message Transfer Service, for the transfer of messages, have been defined:

1. The <u>submission</u> interaction, during which the originating User Agent transfers to the Message Transfer Service the message and its control.

2. The <u>delivery</u> interaction, during which the Message Transfer Service transfers to the

* The term "service" is used herein in the specific sense as defined in the Reference Model for Open Systems Interconnection (i.e. as a <u>capability</u> provided to users).

recipient User Agent the message and its control.

The information required to invoke the services of the Message Transfer Service is passed with the message to the Message Transfer Service during submission. Likewise, the information related to the services performed by the Message Transfer Service is passed to the recipient User Agent during delivery.

2.2 <u>The Message Transfer Agents</u> The Message Transfer Agents are the logical components which provide, through co-operation, the capabilities of the Message Transfer Service. The functions performed by the Message Transfer Agents to provide the Message Transfer Service include:

1. The mechanisms to forward a message from originator to recipient User Agent.

2. The ability to perform the submission and delivery interactions with the User Agents.

2.3 <u>User Agents</u> The User Agent is the logical component of the Message Service that interacts directly with the user. A User Agent can be thought of as the projection of that portion of the user visible in the Message Handling Facilities environment; the User Agent is the only aspect of the user known (i.e., visible, nameable) within the Message Service.

A User Agent represents its user to other User Agents (which are representatives of their respective users) and to the Message Transfer Service.

Certain services require co-operation between User Agents. In order to co-operate, the User Agents communicate using the capabilities provided by the Message Transfer Service. The functions performed by User Agents are listed below:

1. Provide the capabilities necessary for users to prepare messages.

2. Perform the submission dialogue with the Message Transfer Service.

3. Co-operate with other User Agents via the Message Transfer Service.

4. Perform the delivery dialogue with the Message Transfer Service.

5. Provide capabilities necessary to present messages to users.

6. Provide capabilities to assist the user in dealing with messages (e.g., file, retrieve, and forward).

3. LAYERED MODEL FOR MESSAGE HANDLING FACILITIES

In this section, the layered representation of Message Handling Facilities is described. The layered model for Message Handling Facilities serves the following purposes:

1. To allow the principles and techniques (e.g., layering) developed for the Reference Model for Open Systems Interconnection to be applied to Message Handling Facilities.

2. To identify the protocols and interfaces required for Message Handling Facilities.

3. To allow the protocols required for Message Handling Facilities to be related to specific layers of the Reference Model for Open Systems Interconnection.

3.1 <u>The Layered Model for Message Handling Facilities</u>. The layered model for Message Handling Facilities consists of two layers: the User Agent layer and the Message Transfer layer. The User Agent layer contains the logical entities* which provide the User Agent Services and the Message Transfer layer contains the logical entities which provide the Message Transfer services.

Three configurations of systems are considered:

1. Systems that contain User Agent Entities (S1),

2. Systems that contain a Message Transfer Entity (S2), and

3. Systems that contain both User Agent and Message Transfer Agent Entities (S3).

All three types of systems and the protocols that operate between the various entities within each system are illustrated in Fig. 2.

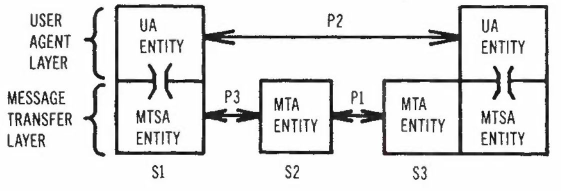

Figure 2. Layered Model for MHF.

Appendices A and B describe the services provided by the User Agent layer and the Message Transfer layer, respectively. These Appendices have been taken directly from the November 1981 Draft Recommendation for Message Handling Systems (version 2).

3.2 <u>Logical Entities Within The Layered Model For Message Handling Facilities</u> Logical entities appear in each layer of the model. These entities are responsible for providing the services of the layer by performing functions in co-operation with each other. Entities within the same layer of the model communicate by means of a protocol.

There are three types of entities in the layered model for Message Handling Facilities: the User Agent Entity, the Message Transfer Agent Entity and the Message Transfer Service Access Entity.

* In this paper the term "entity" is used in the same sense as in the Reference Model for Open System Interconnection.

The User Agent entity performs the functions required in order to provide the User Agent services. The User Agent entity makes use of the services provided by Message Transfer Agent entities in the Message Transfer Layer. Thus the set of services available from User Agents is the resultant of services provided by the Message Transfer Layer and those provided by the User Agent entity.

The Message Transfer Agent entity performs the functions required to provide the Message Transfer Service (e.g., store and forward message transfer) see Appendix B; this is accomplished, in part, through co-operation with other Message Transfer Agent entities.

The Message Transfer Service Access entity makes the services of the Message Transfer layer available to User Agent entities at the Message Transfer layer/User Agent layer boundary.

4. PEER PROTOCOLS WITHIN THE MESSAGE HANDLING FACILITIES LAYERED MODEL

There are three protocols defined in the layered model, refer to Fig. 2.

Protocol P1 is the protocol used between Message Transfer Agent entities in order to transfer a message between source and destination. The P1 protocol provides the signalling capabilities necessary to provide the store and forward Message Transfer Service. These capabilities include routing, addressing and recovery functions.

Protocol P3 is the protocol used between a Message Transfer Service Access entity (MTSAE) and a Message Transfer Agent entity. This protocol provides the functions to allow a MTSAE to provide the User Agent with access to the message transfer services when the User Agent (and MTSAE) and MTA entities are not within the same system.

The services provided to a User Agent and the way these services are invoked are the same, independent of whether the MTSA entity and the MTA entity are colocated or reside in different systems (and thus make use of protocol P3 to invoke the message transfer capabilities).

A message, when submitted by a User Agent entity, consists of a message content part and a message envelope part. The envelope part contains the information required by entities within the Message Transfer layer in order to provide message transfer services. The message envelope is required by both the P1 and P3 protocols.

Protocol P2 is the protocol used between communicating User Agents in order to permit co-operation in providing User Agent services to the user of Message Handling Facilities. Appendix A describes the User Agent services currently envisioned.

5. NAMING

In Message Handling Facilities (MHF) a distinction has been made between users of MHF which lie outside the MHF environment and their application layer surrogates - user agents - which are the representatives of the user and are part of the MHF environment.

APPENDIX A

Version 2 of Draft Recommendation X. - MESSAGE HANDLING SYSTEMS: INTER-RELATIONSHIPS AND CONTROL PROCEDURES

A. Co-operating User Agent Services

A.1 Definitions

A user agent layer service is a capability provided by the UAl to users at the boundary of the UA and the user. Note: The MTL services provided to UA's are provided to users through their UA's.

A.1.1 Advice on Recipient Content Capabilities (SF76)

This service is invoked by the originator on his UA to obtain the list of content types that can be presented to a specific recipient.

This service was discussed exhaustively without conclusion and is a subject for further study.

A.1.2 Content Converted Indication (SF80)

This service must be associated with a delivery or receipt service when a conversion function has been executed during delivery or receipt. The initial and final content types are indicated to the recipient.

A.1.3 Content Format Designation (SF100)

This service allows a description of the type of content designation (for example, text, image or audio) as well as format characteristics peculiar to that content type (for text, the number of characters per line and number of lines per page). The question of at what protocol level the type code is passed is left for further study.

The content format designation may actually be the criteria used by the recipient's UA to determine whether or not to accept delivery of the message. If so, this should not be listed as a separate service but instead should be incorporated as part of the content type incompatibility indication service.

A.1.4 Content Type Incompatibility Indication (SF81)

This service indicates to the originator that his message has not been delivered or received for reasons of incompatibility between the content type and the recipient content capabilities, and gives the list of the recipient content capabilities. This service must be associated with a non-delivery or non-receipt service.

Question: If delivery of the message is not accepted by the recipient's UA, can the service be considered a co-operating UA service?

This service was discussed exhaustively without conclusion and is a subject for further study.

A.1.5 Cross Referencing (SF41)

This service allows users to trace a chain of correspondence by examining the citations of one or more previously transmitted messages. Such a service might be implemented by a cross-reference field to be created by the originating UA and interpreted by the recipient's UA. This service presumes that there is some means of unambiguously identifying previous messages. The recipient's UA may show the reference of a delivered message to the recipient, and may show the referred message content on the basis of cross reference information in compliance with the user's request.

A.1.6 Encryption (SF64)

Encryption is the enciphering of all or part of a message's content. Encryption is used to keep a message from being "understood" by those who are not authorized to inspect it. The recipient's UA must decrypt the message that has been encrypted by the originator's UA.

A.1.7 Message Circulation (SF39)

This service allows a message originator to specify that a message should be serially distributed to a set of recipients. It is performed by including an ordered list as a part of the message. The message is sent to the first recipient on the list. The recipient will send the message to the second recipient on the list, perhaps after commenting on or adding to the message. During circulation, forwarding to the next recipient on the list is executed by each recipient's UA in compliance with the originator's request. This continues until all of the recipients on the list have received the message. If a circular pattern of circulation is desired, the originator may include himself as the last UA on the list.

Note: There is some disagreement on the control an originator may exert over the circulation pattern. In particular, can an individual in the chain of circulation abort the circulation and, if so, must the originator be so informed? Some people think that these matters are not intrinsic to the service and need not be specified; others think that the specification is necessary.

A.1.8 Message Expiry (SF10)

This service allows an originator to specify a date and time after which a message is no longer valid. The recipient's UA may decide on the basis of that indication to take action such as deleting or filing the message. This service might be supported by an "expiry field" containing the date and time of message expiration.

Note: The originator cannot specify what action the recipient's UA must take. This is the sole prerogative of the recipient.

A.1.9 Message Reissuing (SF40)

This service allows a message recipient to send all or part of one or more messages to a new set of recipients. The final recipient can determine the message originator and all intermediate recipients of the message.

Information to be included in re-issuing includes the content of the reissued message, the header information supplied by the originator of the reissued message, and the posting information supplied by the UA and/or MTL when the reissued message was originally transferred. All of the information about the forwarded message is contained within the content of the forwarding message.

Note: There is some question as to whether reissuing is concerned solely with whole messages (that is, only whole messages may be reissued) or whether, on the other hand, it may be possible to reissue parts of messages. It may also be desirable to indicate the intent of the reissuing, for example, for action or information. These matters are for further study.

A.1.10 Multi-Part Contents (SF23)

This service allows the originator to place two or more items into the contents of a single envelope, which is directed to a single common set of recipients. This service is classified as co-operating UA because the MTL has no knowledge of the multi-part nature of the envelope's contents. Fig. 3 captures the nature of the service.

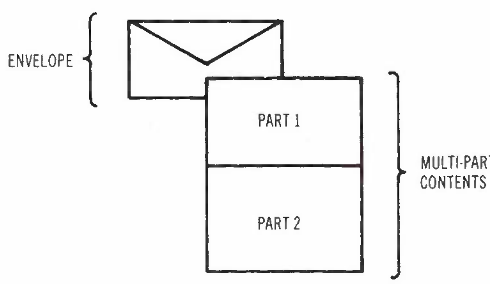

Figure 3. Multi-Part Contents.

Example 1: An author wishes to send several contributions to a collaborator within a single envelope and with a single covering note.

Example 2: It may be possible to save money by including several short messages within one envelope.

A.1.11 Obsoleting (SF8)

This service allows a message originator to include information in a message that specifies that a previous message is now obsolete. The originator may provide an indication of a date and time after which the new message is valid. Action on the basis of that indication is taken by the recipient. The action to be taken when one message obsoletes another is left for further study.

For relating a new message with the initial message, information by which a message is uniquely identified is necessary. This information for message identification is given by the originator's UA.

Note: It was agreed that this service may be viewed as one of several possible applications of cross referencing and may be combined with the text on cross referencing in later versions of this document.

A.1.12 Originator Designation (SF31)

This service allows the message recipient's UA to distinguish users who participated in the message origination process. One possible categorization is as follows:

1. The user(s) who prepare the contents of the message are called its authors.

2. The user(s) who assume responsibility for sending the message are users whom the message is from.

3. The user who actually transmits the message is called its sender.

The degree to which the message's author, sender, and the person assuming responsibility for the message need to be distinguished is left for further study. How much of this information can be passed to the recipient's UA as part of normal delivery and to what extent the information in these fields will be authenticated are also left for further study.

A.1.13 Receipt Notification (SF11)

This service allows an originator of a message to request notification of the receipt of the message by its recipient. The originator may specify that the notification be directed to a third party. The recipient's UA is responsible for generating the receipt. The recipient's UA could generate receipt notification at either of two different points:

1. At the time when the recipient is first alerted that the message has been delivered. The notification may include who was alerted and when. (This service should be identified separately as alert notification.)

2. At the time when the recipient first examines the message. Notification may include who examined the message and when.

The recipient's UA may perform receipt notification either automatically or with the recipient's permission. The message originator should be aware that positive receipt notification does not constitute proof that the recipient has been alerted of the message or has examined it. The recipient's UA may be unable to detect terminal failures or someone else's use of the the recipient's password. In such situations the UA may incorrectly believe that receipt has occurred.

A.1.14 Reply to Designation (SF42)

This service allows the message originator to designate the recipient of a reply to the message. The message reply is normally directed to the originator, but the originator can use this service to request that responses be sent to a different user. This enables the recipient's UA to display the reply-to name to the recipient. It also makes it possible to automatically provide the destination address to a message reply so that the recipient can send the message reply without designating a destination.

A.1.15 User Composition Date (SF 101)

This service allows an alternate method of referencing messages. The recipients UA might use the user composition date as one of the parameters in accessing a previously transmitted message.

This and related services may transcend the bounds of CCITT concern. Specifically, such services may belong more appropriately in the world of office automation.

Note: The posting, as opposed to composition date, might not be available to the originator. Therefore, the service stands as defined for the present time.

A.2 Categorization

Most co-operating UA services are visible to the user, and all can be obtained through an appropriate access point.

Services visible to the user are classified as follows:

1. Basic service elements (B), which are inherent in the service.

2. Essential user facilities (E), which are to be made available internationally.

3. Additional user facilities (A), which may be available in certain systems, and which may also be available internationally.

Facilities can be obtained by the user for an agreed contractural period, or on a per message basis.

Table 2 [to be supplied] tentatively categorizes co-operating UA services as indicated above.

APPENDIX B

B. MESSAGE TRANSFER SERVICES

B.1 Definitions

A message transfer layer service is a capability provided by the MTL to UAE's at the boundary of the MTL and the UAL.

B.1.1 Submission and Delivery

B.1.1.1 Normal Delivery (SF15)

This service provides the originator's UA with the capability to specify that the message may be delivered by the MTL after urgent delivery messages and before low-priority delivery messages at the discretion of the MTL.

B.1.1.2 Urgent Delivery (SF6)

This service provides the originator's UA with the capability to indicate to the MTL that a message must be delivered before normal and non-urgent messages at the discretion of the MTL.

Note: At any place in the MTL urgent messages may go to the front of any queues of messages, but no particular time is assumed for delivery.

B.1.1.3 Non-Urgent Delivery (SF84)

This service provides the originator's UA with the capability to specify that the message may be delivered by the MTL after urgent and normal delivery messages, at the discretion of the MTL.

B.1.1.4 Timed Delivery (SF1)

This service provides the originator's UA with the capability to constrain the date and time of a message's delivery. This service requires further refinement.

Note: The originator's UA may request that the message be delivered no sooner than a specified date and time, no later than a specified date and time or both. For the first case, delivery will take place as close to the date and time specified as possible, but not before. In the second case, delivery is cancelled if unaccomplished by the specified date and time. Using an indication of both the earliest and latest delivery date and time allows for delivery at a specified instant with some minimum tolerance.

Timed submission realized within the originator's UA is not implied by this service.

B.1.1.5 Submission Time Stamp (SF88)

This service provides the UA's with the date and time at which a message was submitted by the originator's UA.

B.1.1.6 Delivery Time Stamp (SF89)

This service provides the UA's with the date and time at which a message was delivered to the recipient's UA.

B.1.1.7 Envelope Identification (SF90)

This service provides the UA's with a unique identification for each message envelope.

Notes:

1. This envelope identification can be used by the UA's as an envelope reference for such services as delivered message retrieval and delivery cancellation.

2. This envelope identification can be used by the MTL for such services as delivery notification and non-delivery notification.

B.1.1.8 Multi-Destination Delivery (SF28)

This service provides the originator's UA with the capability to specify that a message is to be delivered to a set of two or more destinations. A destination is either a recipient's UA or a distribution list.

Simultaneous delivery to all destinations is not implied by the service.

B.1.1.9 Distribution List (SF29)

This service provides the originator's UA with the capability to specify that a message is to be delivered to a set of recipients' UA's. A defined set of recipients' UA's is assigned a reference name. The originator's UA specifies the reference name but not each recipient's UA explicitly. Simultaneous delivery to all recipients' UA's is not implied by the service.

Notes:

1. This service is supported by a distribution list database. A distribution list may be accessible to only an individual originator's UA, or to a wider set of originators' UA's. Additional services must be provided allowing creation, deletion and modification of distribution lists.

2. Various other services may be involved on a per-recipient's UA basis.

3. It may also be possible to send to a group of recipients' UA's by specifying a general set of attributes. This point requires further study.

B.1.1.10 Originator's UA Requested Alternative Recipient's UA (SF12)

This service provides the originator's UA with the capability to specify an alternative recipient's UA to which the message will be delivered if it cannot be delivered to the intended recipient's UA. More than one alternative recipient's UA may be specified.

Note: The impact of this service on delivery notification and non-delivery notification requires further study.

B.1.1.11 Recipient's UA Requested Redirection (SF13)

This service provides the recipient's UA with the capability to specify an alternative recipient's UA to which a message shall be delivered.

Examples of such service are:

1. Designating another recipient's UA to receive his messages and act on his behalf.

2. The recipient has moved, uses another UA and wants his messages to be delivered to the new UA.

B.1.1.12 Limited Submission (SF91)

This service provides the originator's UA with the capability to have its submitted messages restricted by the MTL. The UA indicates to the MTL a limited submission list of recipients' UA's to which messages may be sent. The MTL will check the recipient's UA designation in each message submitted by the originator's UA and will attempt to deliver the message only if the recipient's UA designation is in the limited submission list.

Notes:

1. If a UA X is in the limited submission list of a UA Y and if UA Y is in the limited delivery list of UA X, then X and Y are members of a closed user group.

2. The mechanism by which the UA indicates and updates the limited submission list needs to be defined.

B.1.1.13 Limited Delivery (SF92)

This service provides the recipient's UA with the capability to have restrictions placed by the MTL on the messages to be delivered to it. The UA indicates to the MTL a limited delivery list of originators' UA's whose messages may be delivered. The MTL will check the originator's UA designation in each message to be delivered to the recipient's UA, and will deliver it only if the originator's UA designation is in the limited delivery list.

Notes:

1. This service, in association with the limited submission service, may provide the closed user group service.

2. The mechanism by which the UA indicates and updates the limited delivery list needs to be defined.

B.1.1.14 Closed User Group (SF63)

This service is for further study.

B.1.1.15 Non-Delivery Notification (SF93)

This service provides the originator's UA with a notification that the message(s) were not delivered to the recipient's UA.

The reason the message was not delivered should be included in the notification. A set of the non-delivery reasons shall include at least the following:

1. The recipient's UA is unknown to the MTL. This case will probably be due to an error on the part of the originator's UA or because the intended recipient's UA no longer exists.

2. Message transfer between the originator's UA and the recipient's UA is not permitted, for example, due to closed UA group restrictions.

3. There is an unresolvable incompatibility between the content type and the recipient's UA content types capabilities.

4. A latest delivery time specified by the originator's UA in the timed delivery service has passed.

5. The recipient's UA, which does not request hold for delivery service, has been out of service or otherwise unable to accept delivery for a prolonged time.

B.1.1.16 Delivery Notification (SF5)

This service provides the originator's UA with a notification that the message(s) have been successfully delivered to the recipient's UA.

Note: Delivery notification carries no implication that any user action such as reading the message contents has taken place. Delivery notification is sent directly to the originator's UA using the validated designation of originator's UA. It is related to the original message by means of the message identifier and contains the date and time of delivery. In the case of a multi-destination message, a delivery notification may refer to any or all copies of the original message.

B.1.1.17 Prevention of Non-Delivery Notification (SF82)

This service provides the originator's UA with the capability to request that the MTL not return a non-delivery notification.

B.1.1.18 Delivered Message Storage (SF94)

This service provides a UA with the capability to request that the MTL store a message after delivery and keep the message for possible retrieval during an agreed period of time.

B.1.1.19 Envelope Encryption (SF95)

This service provides the originator's UA with the capability to have the envelope of a message encrypted by the MTL.

Note: This service is for further study, together with a service providing encryption of the message.

B.1.1.20 Delivery Cancellation (SF7)

This service provides the originator's UA with the capability to stop the delivery of a previously submitted message. If the message has already been delivered, then the cancellation attempt will fail. The message originator's UA is notified of the result of the cancellation attempt.

Note: It may be difficult to cancel the delivery of messages that were not sent using timed delivery. The originator's UA identifies the message whose delivery is to be cancelled by means of its message identifier.

B.1.1.21 Security Classification (SF60)

This service is for further study.

B.1.1.22 Route Selection (SF96)

This service is for further study. The intent is to allow an originator's UA to specify a specific route for a message.

B.1.1.23 On-Line Subscription (SF67)

This service is for further study.

Notes:

1. The on-line subscription service is intended to enable a user to subscribe dynamically to the message handling service.

2. Attention is drawn to the on-line registration facility mentioned in Recommendation X.2 and defined in Recommendation X.15.

B.1.2 Conversions

B.1.2.1 Originator's UA Content Type Indication (SF97)

This service provides the originator's UA with the capability of specifying to the MTL an indication of the content type of the submitted message.

B.1.2.2 Recipient's UA Content Type(s) Indication (SF98)

This service provides the recipient's UA with the capability of specifying to the MTL an indication of the content type(s) of messages that can be delivered to that UA.

B.1.2.3 Explicit Content Type Conversion (SF78)

This service provides the UA's with the capability to request the MTL to perform a specified conversion.

Note: Further study is required concerning the combination of conversion services.

B.1.2.4 Implicit Content Type Conversion (SF77)

This service provides the UA's with the capability to request the MTL to perform any necessary conversion.

Note: If conversion between the content type and the recipient's UA content capabilities is necessary, then the most appropriate conversion is executed.

The possible conversions require further specifications.

B.1.2.5 Specific Conversion Prohibition (SF79)

This service provides the UA's with the capability to indicate to the MTL which conversion shall not be used.

Note: When a content conversion is useful, the chosen conversion must not belong to the list of prohibited conversions indicated by the UA's.

B.1.2.6 Content Type Converted Indication (SF80)

This service provides the recipient's UA with an indication that a content type conversion function has been executed by the the MTL. The initial and final content types are indicated to the recipient's UA.

B.1.3 Query

B.1.3.1 Address Information Enquiry (SF62)

This service provides the UA's with the address (delivery slot) associated with a given name (attribute list) belonging to a potential message recipient.

Note: The address is determined by consulting a database which associates names with addresses. An address information enquiry is initiated by a UA and processed by the MTL. The exact location within the MTL at which processing takes place depends upon the architectures of the MTL and the database containing the names and addresses.

There are a number of possible responses to an address information enquiry. If there is no potential recipient associated with the name, then a failure response is returned. If the name can be uniquely associated with a potential recipient, that recipient's address is returned. If the name can be associated with more than one potential recipient, then one of three actions is taken:

1. An "ambiguous name" error is returned.
2. The addresses of all potential recipients are returned.
3. The full names and addresses of all potential recipients are returned.

When the address information enquiry is made, the UA may specify which action should be taken in this case.

B.1.3.2 Advice on Recipient's UA Content Capabilities (SF76)

This service provides the originator's UA with the list of content types that can be presented to a specific recipient's UA.

B.1.3.3. Audit Trail (SF70)

This service provides the UA's with detailed information for testing and control purposes. The information can be delivered directly after execution or stored. In the latter case, the information can be retrieved at an arbitrary moment.

B.1.3.4. Proof of Submission and/or Delivery (SF85)

This service provides the originator's UA with the capability to request a proof from the MTL that the message was indeed submitted and/or delivered to the intended recipient's UA.

Note: The proof depends on all parties trusting the MTL and is intended to help resolve disputes that may arise when one user claims to have sent a message, and the alleged recipient claims not to have received it.

When the originator of a message requests this service, the MTL records some information associated with the message. This may be:

1. The message identifier only.
2. The message envelope.
3. The message contents.
4. The status of the message, that is, delivered or not.

The MTL returns to the originator's UA - along with the message identifier - a tag that contains the message identifier and perhaps some other information about the message in encrypted form.

At a future date, the originator or some other party to whom the originator reveals the message identifier and tag may then supply the message identifier and tag to the MTL, along with a request that the MTL verify that the message was submitted or delivered. The MTL then decrypts the tag, and checks that the message identified in the decrypted tag agrees with the message identifier supplied. The intention is to prevent a user from generating tags at random in an attempt to have the MTL reveal information. If the tag is consistent with the message identifier, the MTL gives a response to the requestor's UA, which depends on what information about the message was originally stored. This may range from a simple confirmation that a message with the supplied message identifier was submitted, to a complete copy of the message, along with a statement of to which UA it was successfully delivered.

The standardization of the presentation of this proof to the requestor (that is, the originator, the recipient, or a third party) is for further study.

B.1.3.5 Delivered Message Retrieval (SF99)

This service provides a UA with the capability to request that a copy of a previously delivered message be retrieved from MTL storage and transferred to the UA.

B.1.3.6 Charging Information (SF 72)

This service provides the UA with information that makes it possible for the UA to calculate the charge.

B.1.3.7 Tariff Enquiry (SF71)

This service provides the UA's with the capability to request information about the tariffs of the various usage possibilities of the services. This service requires further study.

B.1.4 Status and Inform

B.1.4.1 Hold for Delivery (SF18)

This service provides the recipient's UA with the capability to request the MTL to hold its messages for delivery for a certain period of time.

Notes:

1. The UA's may indicate a period of time for this hold, or indicate to the MTL when it is ready for delivery.

2. The definition of a maximum period of time is for further study.

3. The impact of this service on non-delivery notification and delivery notification also requires further study.

B.1.4.2 Alarms (SF47)

This service provides the UA's with an indication that an abnormal condition has occurred or will occur in the MTL. The reason should be included in the alarm.

Note: The possible reasons require further specification.

B.1.4.3 Resource Status and Resource Warning (SF 38)

This service is for further study.

B.2 Categorization

Most message transfer services are visible to the user. Together with the services provided by the UAL, they can be obtained through an appropriate access point.

Services visible to the user are classified as follows:

1. Basic service elements (B), which are inherent in the service.

2. Essential user facilities (E), which are to be made available internationally.

3. Additional user facilities (A), which may be available in certain systems, and which may also be available internationally.

Facilities can be obtained by the user for an agreed contractural period, or on a per message basis.

Table 1 tentatively categorizes message transfer services as indicated above.

TABLE 1. MTL SERVICE CATEGORIZATION

	B	E	A	Further Study
Submission and Delivery:				
Normal Delivery	X			
Urgent Delivery		X		
Non-Urgent Delivery			X	
Timed Delivery		X		
Submission Time Stamp		X		
Delivery Time Stamp		X		
Envelope Identification	X			
Multi-Destination Delivery		X		
Distribution List			X	
Originator's UA Alternative Recipient's UA			X	
Recipient's UA Requested Redirection			X	
Limited Submission			X	
Limited Delivery			X	
Closed User Group			X	
Non-Delivery Notification	X			
Delivery Notification		X		
Prevention of Non-Delivery Notification			X	
Delivered Message Storage			X	
Envelope Encryption			X	(X)
Delivery Cancellation			X	
Security Classification				(X)
Route Selection				(X)
On-Line Subscription				(X)
Conversions:				
Originator's UA Content Type Indication	X			
Recipient's UA Content Types Indication	X			
Explicit Content Type Conversion			X	
Implicit Content Type Conversion			X	
Specific Conversion Prohibition			X	
Content Converted Indication	X			
Query:				
Address Information Enquiry				(X)
Advice on Recipient Content Capabilities			X	
Audit Trail			X	(X)
Proof of Submission and/or Delivery			X	(X)
Delivered Message Retrieval			X	
Charging Information			X	
Tariff Enquiry			X	(X)
Status and Inform:				
Hold for Delivery			X	(X)
Alarms				(X)
Resource Status and Resource Warning				(X)

BIOGRAPHY

Paul D. Bartoli is currently Supervisor of the International Standards Planning Group at Bell Laboratories which is responsible for representing the Bell System on data communications in various national and international standards organizations. He has been involved in data communications protocol architecture for the past five years. He actively participates in the work of CCITT Study Group VII and ISO/TC97/SC16 on the Reference Model for Open Systems Interconnection in the area of the architecture of the Application and Presentation Layers and file transfer services.

Mr Bartoli is Vice-Chairman of the USA ANSI group responsible for the Application and Presentation Layers of the Reference Model. He has been involved in the work on Message Handling Facilities since its inception in CCITT.

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