

**Handbook
of
Data Communications**



Handbook of Data Communications

'My department is in possession of full knowledge of the details of the invention [the telephone], and the possible use of the telephone is limited'

Engineer-in-Chief, British Post Office, 1877

'One day, every town in America will have a telephone'

Mayor of a small American town, circ. 1880

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Introduction

This book draws heavily on an earlier NCC book with an identical title, first published in 1975. The material of the earlier book was prepared by staff at Post Office Telecommunications (as it then was) and was published on behalf of the PO by The National Computing Centre. In the seven years which have elapsed since it first appeared, the book has enjoyed considerable success both in the UK and overseas.

Two factors prompted the decision to produce this new book. In the first place, in the intervening period there have been dramatic changes in computing and communication technology and concepts, and the original book is clearly out-of-date in a number of respects. Secondly, there was the equally compelling reason that stocks of the book were nearing exhaustion, whilst there was strong evidence of a continuing demand for the publication.

These considerations encouraged us to the view that a new book should be produced: the present volume is the result. Before embarking upon the task we discussed the proposal with British Telecom, who kindly gave their blessing to the venture, subject to satisfactory arrangements regarding copyright on material which has been reproduced from the earlier book. British Telecom also indicated that on this occasion, for reasons which we accept and respect, they did not feel able to participate directly in the task. Therefore, apart from the material reproduced from the earlier volume, The National Computing Centre assumed responsibility for preparing and assembling new material and for any restructuring of the book.

It is not a trivial task to compile a book such as this, covering a subject area which has experienced such rapid changes in recent years – a process

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that can be expected to continue throughout the next decade. Inevitably, the ideal solution would have been to completely rewrite the book, but this would have had two major disadvantages: the timescale would have exceeded what we considered reasonable; and the result would itself in turn fall a victim to technological change. We elected for a compromise approach based upon the following guiding principles.

First of all, for reasons that will be shortly explained, we decided to retain the broad structure and balance of topics of the original. Secondly, we decided to retain those parts of the original which had stood the test of time and remained valid; this includes the basic principles and much material which is not easily accessible elsewhere. We nevertheless considered it proper to amend this retained information either in the interest of increased clarity or for stylistic reasons. And finally, we felt it essential to take account of the major technological and conceptual changes which have occurred and which are now exerting a significant influence on data transmission, on the future shape of telecommunications networks, and on the role of data communications generally.

We shall first of all briefly review those topics where major revision is indicated. But before doing so, it is worth quoting a paragraph from the preface to the earlier book:

'Computer and telecommunications technologies are becoming increasingly convergent and the UK Post Office, in conjunction with The National Computing Centre Limited, has produced this Handbook as a contribution to a greater understanding of their interdependence by students of both disciplines'

The phenomenon of convergence is now a commonplace, but its recognition in 1975 in the above context can now be seen to have been remarkably prophetic. Looking back over a distance of seven years we are also reminded of the major technological changes and trends which are bringing about its realisation. These were then either non-existent or barely discernible.

The underlying common thread is digitisation – of transmission and switching, and the representation and storage of information. Although in the mid-1970s digital transmission of speech using PCM was beginning to be applied in the world's telephone networks, the UK Post Office, in common with other PTTs, was still at the stage of formulating its long-term network modernisation plans. Now, most PTTs are committed to

digitisation of speech and data throughout their networks, and in the UK in particular this is beginning to take shape in the form of System X, and private circuit digital services, culminating in the Integrated Services Digital Network.

The present book therefore gives far greater prominence to *digital* transmission technology, as opposed to *analogue*, than did its predecessor.

In the mid-1970s, Packet Switching was starting to be considered as an alternative to circuit switching for data transmission in public switched networks. However, the bulk of experience was largely in the academic and research environment, although the UK PO had decided to launch the Experimental Packet Switched Service; this was touched upon in the earlier volume. Since then there has been rapid progress both in the UK and internationally. In the UK we have a fully operational public packet switched service (PSS); other national telecommunications administrations are introducing similar services, and these are all being progressively interconnected through national gateways. This is an area which obviously requires an expanded treatment.

Major changes are also occurring in the nature of the transmission vehicles. Whereas, in the early part of the 1970s, coaxial cable was the favoured vehicle for terrestrial circuits, and was fast displacing the traditional multistrand copper cables, now optical fibres are set to displace coaxial cable, with satellite transmission opening up totally new dimensions.

Data communications can only achieve its full potential if, in principle, any device (such as a computer or a terminal) can readily access and communicate intelligently with any other device. The eventual goal is to achieve the potential universality of intercommunication for data communications as exists in the world's telephone network. Although the electrical interface standards specified by CCITT and implemented by the PTTs have provided an essential and solid foundation for data communications, a substantial hierarchy of additional standards and protocols is also required.

In the last few years there has been substantial progress in the development and adoption of new protocols, such as HDLC for line control and X25 for packet switched networks. A deeper understanding of the conceptual framework has also emerged. Because of these

developments we have restructured and almost completely rewritten this part of the text, and we have been able to do this within a framework which we hope is a little more systematic and more coherent than has been customary.

These developments have required the formulation and agreement of a complex hierarchy of standards for attaching equipment, and formalised rules governing intercommunication.

With regard to the broad structure, some explanation may be in order for the newcomer unacquainted with the earlier book but who has already read other texts on the subject. Such a reader may be struck by the increased coverage given to the public network and its operation, compared with other texts. The reason is that the original handbook arose as a by-product of courses on data transmission jointly organised and operated by the Post Office and The National Computing Centre. The courses were aimed at two categories of people: the telecommunications specialists who wished to expand their knowledge of computer communications, and the dp professionals who wanted to find out more about the transmission and telecommunications area. It is this background that largely accounts for the unique flavour of the original, and which we decided to retain in the present volume. The decision has been amply justified by the comments we have received and our experience in running courses. Whilst it is certainly *not* essential for the dp professional to have a particularly detailed knowledge of the telecommunications infrastructures, many have found it rewarding to gain an insight into what lies beyond the modem interface. This insight has often resulted in a vastly increased respect for the achievements of telecommunications engineering. For the telecommunications engineer traditionally preoccupied with voice requirements, and who is now having to get to grips with the world of data communications, information technology, the electronic office, etc, the book also contains some familiar landmarks on the road to finding out more about data communications.

The book is organised so that roughly the first half is concerned with transmission and switching theory and hardware. It starts with a discussion of basic principles, then moves on to describe the public switched telephone network. Identification of the limitations of the analogue telephone network provides the transition to data transmission and its requirements, and how these are met under analogue transmission, and the enormous improvements brought about by conversion to digital

transmission and switching technology. This part of the book concludes with a review of British Telecom's network modernisation strategy and plans.

From this point, the text moves into the area of data communications proper. It commences with an overview of *data communications systems* as assemblages of various components such as transmission circuits, modems, multiplexers and the like. The subject is discussed in terms of the physical arrangements for linking the various elements together, and the functional or conceptual architectures necessary to ensure that the system as a whole operates in a disciplined and coordinated manner.

Following this, there is an extended discussion of data communications standards, protocols, and error control procedures. This is perhaps the most abstract part of the book, but a vitally important one and an area in which there have been major developments in the last few years. In the literature the topics covered are not always presented in a clearly understandable and logically coherent manner, and this we have tried to remedy.

Data communications systems can never be completely left to themselves: faults have to be detected and remedied, performance monitored and so on. In short, the system has to be managed, and the penultimate chapter discusses in general terms some of the more important topics which come under this heading.

Data communications, comprising the whole body of principles and techniques described in this book, results from the marriage of telecommunications and computing technology. The computer is a fairly recent innovation but telecommunications goes back much further; to 1837 in fact, when Wheatstone invented the electric telegraph. Together, these disciplines provide the basis for the Information Technology Revolution which is now underway. In the final chapter, 'Into the Future', we try to offer a glimpse into this new world by describing the main technological driving forces, the expanding and novel opportunities that are emerging and the potential impacts on society.

In the process of preparing the book a major problem was in deciding what parts of the original text to leave out. It was impossible to include everything in addition to the new material.

Portions of the text were discarded for a variety of reasons, including: present-day relevance, expediency, it being considered simpler to rewrite

rather than to merge fragments of text, and several other practical considerations. In particular, it should be noted that we have omitted detailed descriptions of specific UK and international telecommunications services which had their own separate chapters in the original version. Because of the rapid changes which are occurring, and the speed at which new services are being introduced or expanded, this information very quickly becomes out-of-date, and we decided that it would be prudent to exclude it.

We have already indicated the kind of mixed audience to which the earlier version was directed, and we feel that this still applies, with one or two qualifications. There is some significance in the use of 'Handbook' in the title. Whilst the book could usefully serve as a textbook – and we would not wish to dissuade the reader from using it in this way – we feel that a complete newcomer would gain added benefit if the book were supplemented by a more basic text. Above all, the book serves as a reference text, to be dipped into as the occasion requires; either to refresh the memory, or to supply information not always easily accessible.

In conclusion we hope that the book turns out to be a worthy successor to its predecessor and enjoys a similar success.

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Senior Consultant
NCC Office and Communications
Systems Division

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