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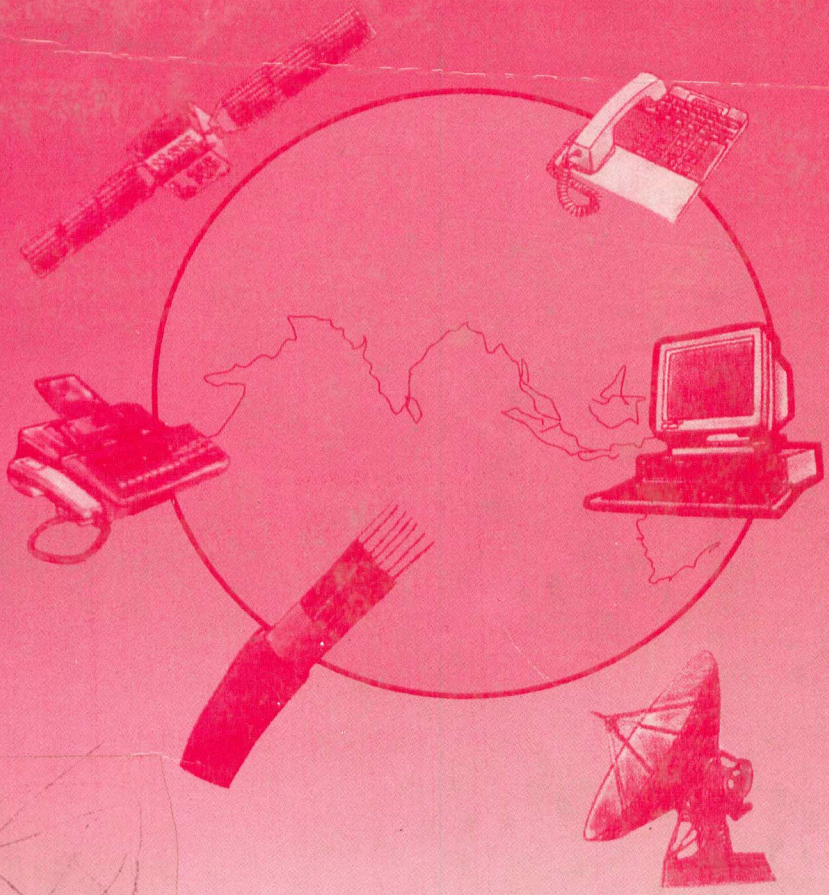
Telecommunication Switching Systems and Networks



Thiagarajan Viswanathan

TELECOMMUNICATION SWITCHING SYSTEMS AND NETWORKS

Telecommunication Switching Systems and Networks

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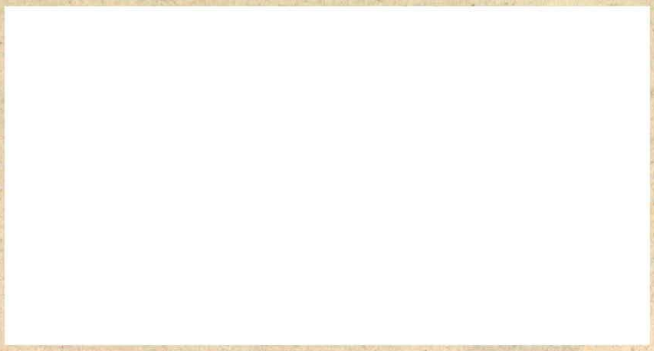

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TELECOMMUNICATION SWITCHING SYSTEMS AND NETWORKS
by Thiagarajan Viswanathan

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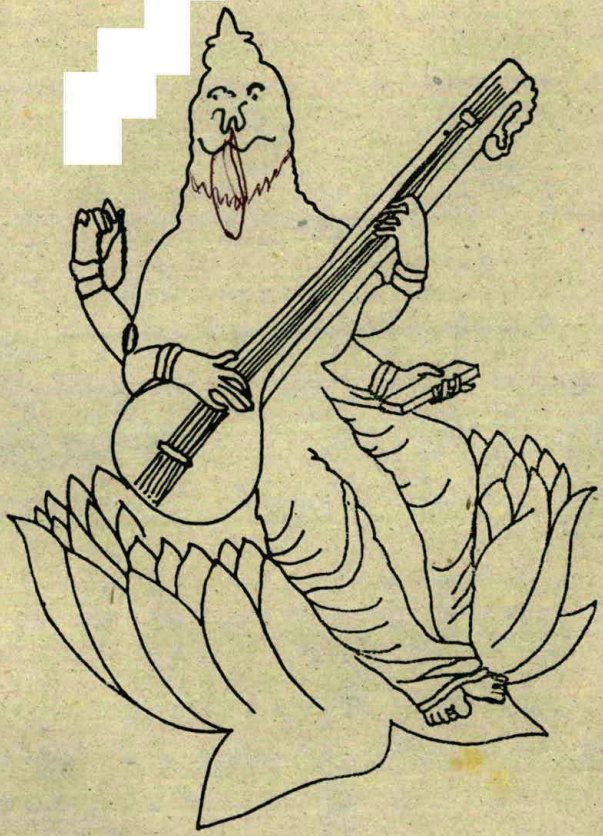

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Foreword

For a number of years, it has become the fashion to write books on analytic themes rather than on topics pertaining to practical systems and their synthesis. That has been so mainly for two reasons: Firstly, analytic themes lend themselves to elegant pedagogic presentation while engineering practices do not. Secondly, practical systems change rapidly, and become dated pretty fast while analytical theory remains valid for long periods of time. In any case, there are few books available on the current practice of telecommunication systems. That leads to a vicious circle – in the absence of books, the topic is not taught in universities, and as it is not taught in universities, books are not written. Thiagarajan Viswanathan has written a book which breaks this vicious circle, and makes a laudable attempt to fill a major gap.

In the next twenty years, we may expect to witness revolutionary changes in telecommunications practice. The foundations for such developments have already been laid in the form of ISDN. Hence, a book on telecommunications systems based on the newly accepted international practices is timely.

In the flurry and excitement of new developments, the tendency is to forget the pioneering past, and thereby lose the historical perspective so essential for scholarly study. I am, therefore, particularly pleased that his book does pay attention to the historical processes in telecommunication switching.

I am happy to commend this book to all telecommunication engineers.

P.V. Indiresan
President
The Institution of Electronics and
Telecommunication Engineers
New Delhi

Preface

Today's telecommunication network is a complex interconnection of a variety of heterogeneous switching systems. Electromechanical and electronic systems, direct and common control systems, and hard-wired and stored program control systems coexist. In a sense, it is a marvel that these systems work in close cooperation to offer a plethora of complex telecommunication services, often involving instantaneous information transfer across the globe. Presently, two important classes of telecommunication networks, viz. public switched telephone network (PSTN) and public data network (PDN) are in wide use. The newly emerging integrated services digital network (ISDN) is expected to be in place in the next 20 years or so as a result of the process of total digitalisation of telecommunication networks currently under way. This text is a treatment on both switching systems and telecommunication networks in a single volume.

The motivation for writing this text came when I taught regular full-semester and short-term courses on 'switching systems and networks' at the Indian Institute of Science, Bangalore. I keenly felt the absence of a suitable text for the purpose. This book is meant to fill this void and is designed for the final year undergraduate or the first year postgraduate students in electronics and communications engineering and allied subjects. It may be difficult to cover the entire text in one semester. Depending on other courses offered and the emphasis given in a programme, a teacher may like to omit one or two chapters in a one-semester course.

I have attempted to give a balanced blend of theoretical and practical aspects in the text. Concepts and system level treatment are given emphasis. Analytical or mathematical treatment is introduced only to the extent required. Worked-out examples are given where considered necessary. All chapters contain exercises, and answers are provided for the selected exercises at the end of the book.

For over 40 years, telecommunications has largely been confined to the private domain of network operators. Research, development and even education have been pursued by a few firms and organisations. It is only recently that a large number of entrepreneurs have entered the field of telecommunications. Such new entrants should find this book to be a valuable asset. The coverage of recent topics like fibre optic communication systems and networks, time division switching systems, data networks, ISDN, and voice data integration schemes should interest the practising professionals.

I have devoted two full chapters to discuss at length, the somewhat outdated Strowger and crossbar systems, for two reasons. The first and most important one is pedagogical. Many fundamental concepts underlying the design of

modern electronic exchanges have evolved from these systems. Secondly, most of the less developed and developing countries including India have operational Strowger and crossbar systems, often in large numbers.

Chapter 1 introduces the subject. In this chapter, the evolution of the telecommunication networks is briefly traced, starting from the invention of the telephone by Alexander Graham Bell and ending with the emerging ISDN. A classification scheme for the switching systems is presented. Basic network structures such as folded, nonfolded, blocking and nonblocking structures are introduced.

Chapter 2 deals with pulse dialling and Strowger automatic switching systems. A set of parameters to evaluate alternative designs of switching systems is introduced in this chapter. These parameters are generic in nature and are used throughout the text to compare different designs.

Chapter 3 discusses the dual tone multifrequency (DTMF) telephones and signalling, the common control concepts, and the crossbar switching systems.

Chapter 4 is devoted to stored program control (SPC) and multistage space division networks. Here, fault tolerant SPC architectures are discussed besides system and application software aspects. The enhanced telecommunication services that become possible with the introduction of SPC are then presented.

Chapter 5 lays the foundation for digital voice transmission. After covering linear quantisation, companding and CCITT *A*-law are discussed. This chapter ends with a presentation on CCITT time division multiplexing hierarchy.

Chapter 6 concentrates on time division switching. First, analog and digital time division switching techniques are discussed. The idea of time multiplexed input/output streams and the corresponding time division switching concepts are then presented. At the end, time-space combination configurations are discussed with real life examples.

Chapter 7 is devoted to fibre optic communication systems which are emerging as a major alternative to coaxial cable systems. This chapter covers types of optical fibres, optical sources and detectors, and deals with power losses in fibre optic systems giving related power budget calculations. This chapter concludes with a discussion on the practical application of fibre optic communication systems in telecommunication networks.

Chapter 8 is on traffic engineering which is the basis for the design and analysis of telecommunication networks. Grade of service (GOS) and blocking probability ideas are placed in proper perspective in this chapter. Basic concepts of modelling switching systems as birth-death stochastic processes are presented. Loss system and delay system models are discussed.

Chapters 9–11 deal with the three most important telecommunication networks: telephone networks, data networks and integrated services digital networks. Chapter 9 provides a comprehensive coverage of the telephone network aspects discussing subscriber loop systems, switching hierarchy, and transmission, numbering and charging plans. In addition, a brief description of

the various transmission systems, viz. coaxial cable, ionospheric, troposcatter, microwave, and satellite communication systems, is given. Besides, a discussion on inchannel and common channel signalling systems is also included. Finally, this chapter presents the introductory concepts of the newly emerging cellular mobile communications.

Chapter 10 opens with a discussion on data transmission over PSTN and provides a detailed treament on open system interconnection (OSI) reference model. It then goes on to present important aspects of local and metropolitan area networks, and satellite based data networks. Basics of fibre optic data networks where considerable research interest lies at present are then dealt with. Other aspects discussed in this chapter include data network standards and internetworking.

In Chapter 11, after briefly discussing the motivation for ISDN, some of the new services that are possible in the context of ISDN are presented. ISDN architecture, user-network interface and ISDN standards are covered in this chapter. It is envisioned that artificial intelligence and expert systems would play a significant role in future telecommunication networks and hence a brief treatise on this topic is given. The chapter concludes with a discussion on some of the voice data integration schemes.

I set out to write this text with an aim of giving a broad, yet fairly in-depth, and up-to-date coverage of telecommunication switching systems and networks. How far I have succeeded in this aim is for the readers to judge. I would be grateful for comments from the readers, especially students, teachers and practising professionals.

T. Viswanathan

Acknowledgements

Many have contributed to the successful preparation of this text. I would like to place on record my grateful thanks to each one of them.

I began writing this text when I was a Professor at the Indian Institute of Science (IISc), Bangalore, but wrote a major part of it while being the Director of the Indian National Scientific Documentation Centre (INSDOC), a constituent establishment of the Council of Scientific and Industrial Research (CSIR) of the Government of India. Financial support for the preparation of the manuscript came from the Curriculum Development Cell at IISc set up by the Ministry of Human Resource Development. The excellent infrastructural facilities of INSDOC and the gracious words of encouragement from Prof. S K Joshi, Director General, CSIR hastened the process of completing the text.

Shri J Gopal of the Department of Telecommunications put in considerable effort and reviewed the manuscript in a time-bound manner. Shri J M Jose, a research fellow at INSDOC, verified the worked-out examples and meticulously perused parts of the manuscript. He also rendered very valuable assistance in many other ways.

Smt. Chandrika Sridhar at IISc and Smt. Sushma Arora at INSDOC rendered their skillful services in word processing the handwritten manuscript. Both of them did their job so efficiently and delightfully that I had no hesitation in revising, modifying and correcting the computerised manuscript many times. Both of them went out of their way to meet deadlines and schedules.

The camera ready copies of the manuscript were prepared at INSDOC using desk top publishing facilities. Shri B Sadananda Rao, Smt. Sarla Dutta and Shri S D Barman contributed significantly to this activity. The rich experience, expertise and the maturity of Shri B Sadananda Rao have been an asset.

All my office staff and a few other colleagues at INSDOC have in some way contributed to this process. In particular, S/Shri P R Gupta, Trilok Singh Negi, Durga Dutt Tiwari and Balwant Singh deserve mention.

The publishers, Prentice-Hall of India, meticulously processed the manuscript with remarkable speed, both during the editorial and production stages, and made valuable improvements.

A number of persons have been well wishers of this activity. Foremost among them are S/Shri N Jayaraman, V Rajaraman, T N Seshan, Dr B B Sundaresan, Y S Rajan and N Pant.

My wife has been a mentor in this effort. When I was overjoyed at having completed some portion, she gently reminded me of the work still left. When I was concerned about not progressing, she took care of even my trivial personal needs, enabling me to devote my full energy on this effort. The text was tried on

my first daughter, a bright student of mathematics, who studied the text and learnt the subject on her own. When she did not understand some concepts, it was an indication for me to revise the concerned portion. When I was excited about some new activities and talked of some 'big things', it was given to my younger daughter to say 'Appa, first finish your book, that is the best service you can render'.

I am overwhelmed, when I think of the fact that there are so many who have worked to make this effort a success although there is only one name printed as author in the text. I am indebted to each one of them.

It is my experience that both science and religion have their roles to play in one's life. While science has helped me to think and reason rationally, religion has carried me beyond the realm of thought and reasoning. A great seer of India has blessed this effort and I feel that he has taken me one step nearer to God through this effort. It is with great humility that I offer this text at the feet of the Supreme Being.

T. Viswanathan