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AMSTERDAM • BOSTON • HEIDELBERG • LONDON
NEW YORK • OXFORD • PARIS • SAN DIEGO
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Newnes is an imprint of Elsevier

Newnes

Newnes
An imprint of Elsevier
Linacre House, Jordan Hill, Oxford OX2 8DP
30 Corporate Drive, Burlington, MA 01803

First published 2004

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

Library of Congress Cataloguing in Publication Data
A catalogue record for this book is available from the Library of Congress

ISBN 0 7506 6271 9

Typeset by Integra Software Services Pvt. Ltd, Pondicherry, India
www.integra-india.com
Printed and bound in The Netherlands

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Preface

The make-up and structure of telecommunications networks has changed dramatically in the past few years. These changes impact on the equipment you purchase, the services you use, the providers you can choose and the means of transporting the data. This book will be of particular benefit to those who want to apply the latest and most effective telecommunications technology immediately. The book commences with a review of telecommunications basics and typical transmission media ranging from copper to fiber optics. This brings everyone up to speed with the fundamentals of telecommunications. Public Telephone network services are then examined with a review of the typical infrastructure (including ISDN and DDN). Narrowband networks are then investigated with a discussion on PABX's and Computer/Telephony integration. The topic of wide area networks and local area networks is then reviewed with a focus on the TCP/IP protocol as applied to telecommunications systems. All the important topics of Internet/IP applications and services is then analyzed with a discussion on topics such as Voice over IP. The meaning and structure of broadband communications is defined and the practical applications of such technologies as ADSL identified. Finally, the fast expanding topic of wireless communications is investigated in considerable depth with a focus on practical applications and breaking developments, which you can use in your work.

Throughout the book you will receive guidance and practical tips from a proven expert about how to apply this technology to your company. Your company may already be looking at operating its own telecommunications system or may be looking at using the systems on the market. With the vast array of equipment and systems and technology now available to you, you need the necessary knowledge to make the best decisions. We believe this book will allow you to achieve your objectives in learning and then applying the fundamentals of telecommunications to your next project.

This book has been designed for those who require a basic but fundamental grounding in telecommunications and will be of special benefit for those who want to apply the technology as quickly as possible.

We would hope that you will gain the following knowledge from this book:

- The fundamentals of telecommunications
- The 'jargon' used in telecommunications
- The 'nuts and bolts' about selecting and installing telecommunications systems
- How to increase the bandwidth by exploiting your existing copper wire more effectively
- How to make 'best practice' decisions on the best and most cost effective access options for your company
- How to apply the latest technologies such as wireless communications
- How to understand and apply high speed access systems such as ADSL and beyond.

Typical people who will find this book useful include:

- Electrical Engineers
- Technicians
- Managers
- Instrumentation Engineers & Technicians
- Process Control Engineers & Technicians

- Project Engineers
- Systems Engineers
- Process Engineers
- Maintenance Engineers
- Sales Engineers
- Engineering Managers
- Network Administrators
- Software Engineers
- Field Technical Support Staff.

A modicum of electrical and data communications knowledge will enable you to maximize your understanding of the material in the book.

1

Introduction to telecommunications

1.1 Telecommunications

The word ‘telecommunication’ is derived from the Greek stem ‘tele’ meaning ‘at a distance’ and the word ‘communications’ meaning ‘the science and practice of transmitting information’. A more useful definition is given in the Dictionary of Communications Technology as ‘a term encompassing the transmission or reception of signals, images, sounds, or information by wire, radio, optic, or infra-red media’.

Telecommunications plays a vital role in international commerce, and in industrialized nations it is an accepted necessity. The telecommunications networks in all countries are linked together to form a global telecommunications network for carrying information of all kinds. The public switched telephone network (PSTN) was originally developed solely for carrying voice communications, but today carries ever-increasing data communication traffic. The Internet uses the PSTN circuits to carry its data, and the phenomenal growth of the Internet has stimulated the growth of data circuit usage in the PSTN. In some countries, Internet traffic accounts for more than half the total PSTN traffic.

Wireless services are having an enormous impact on the growth of telecommunications networks. In industrialized countries they are used increasingly for mobile business communications. On the other hand, in developing countries, they enable many customers in the main population centers to obtain affordable telecommunications services. The telecommunications provider does not have to invest in the very high costs of fixed subscriber distribution plant for the individual customers and can serve thousands of customers from one transmitter site. Service can be supplied almost immediately – in the time taken to purchase a cellular phone, sign a service contract and arrange the network connection by means of a telephone call or data message to the service provider.

1.2 Principles of telecommunications services

Telecommunications services follow these principles:

- The telecommunications networks are used to provide services to the users.
- A service requires the execution of a series of programs by the originating and destination entities.
- The services are decomposed into different layers by the initiating entity, where each layer undertakes a specified portion of the overall service. This makes the services more manageable and allows interoperability between vendors. The OSI reference model explains this layered architecture.

- The telecommunications services include information transfer, signaling, and billing.
- Information is transferred over the network in the form of bits. These bits have different forms depending on the type of the transmission media; electrical signals on copper cables, pulses of light in fiber-optic cables and electromagnetic waves traveling through space in radio signals.
- Signals can be corrupted during transmission due to interference.
- Protocols incorporate error correction and detection mechanisms to overcome errors.

1.3 Chapter overview

Chapter 2 is to familiarize the reader with some of the basic telecommunications concepts. In this chapter the following areas will be discussed; types of channels and their methods of operation, modulation methods as ways of imposing information on the channel, the difference between analog and digital channels and different ways of making connections across the network. The open systems interconnection (OSI) model introduces the concept of layered architectures and the functions of the various layers are explained. More experienced readers may wish to skip this chapter.

Chapter 3 examines some of the different types of transmission media used for physically conveying signals from one point to another. The approach taken will be to explain the fundamental method of operation of each of these transmission media types, introduce the various system components and discuss the application for each type. Some of the main bearer design considerations will be discussed to enable the reader to make an informed decision as to which type of media to use for a particular application. The discussion will commence with systems guided over a physical bearer; namely twisted pair and coaxial copper, fiber-optic cables and the power distribution system. The discussion will then move on to wireless systems; namely microwave radio systems, satellite systems and infra-red transmission, which require no specific bearer and radiate their signals as electromagnetic waves. The emphasis in this chapter is on the fundamental transmission bearer systems, Chapter 6 discusses the methods of carrying information, both analog and digital, on these bearer systems.

Chapter 4 discusses the structure of the PSTN, together with the CCITT signaling system No. 7, which provides a common signaling channel across the digital networks to enable many sophisticated network services, such as ISDN, to be provided.

Chapter 5 discusses various aspects of the voice switching equipment located in a customer's premises. This includes PBX systems, key systems and centrex service. The discussion covers computer telephony integration (CTI), which allows a computer and a telephone to work together so that a user can manage their telephony services using a PC in conjunction with a telephone. For example this allows customer details to pop up on the computer screen when the call is answered.

Chapter 6 considers the different communication approaches used for the provision of services in the public telecommunications network. Fundamentally circuits can be divided into four categories: either analog or digital and each of these can be either switched or leased. First we will consider the switched analog network and then look at the use of dedicated or leased analog circuits. Next the digital services will be discussed beginning with the various types of switched digital services and concluding with various alternatives for dedicated digital services, primarily directed at the large users. In each section the method of operation will be explained, the circuit characteristics described and

the particular advantages the method offers will be considered. This is intended to enable the reader to make an informed choice about the appropriateness of that particular approach for their unique situation.

Chapter 7 examines the available technologies for the provision of broadband customer access at greater than 1 Mbps, including both wired and wireless services. The wired systems discussed include: systems operating over the existing POTS copper pairs, known collectively as xDSL systems, systems used to provide existing cable television services such as hybrid fiber coax (HFC) and their new counterparts such as fiber to the curb (FTTC) and fiber to the home (FTTH). The wireless systems include multi-channel multipoint distribution system (MMDS), local multipoint distribution services (LMDS), and short-range systems such as Bluetooth. This chapter discusses the operation of each of these alternative customer access technologies together with their relative merits and associated performance issues.

Chapter 8 looks at the following aspects of providing local area networks to business customers:

- The various LAN topologies as well as their advantages and disadvantages
- Various media access methods, specifically CSMA/CD, CSMA/CA, token passing and polling
- Various LAN standards with emphasis on IEEE 802.3, IEEE 802.5, IEEE 802.11 and ANSI X3T9.5
- The functionality devices used to interconnect networks: repeaters, bridges, routers, switches and gateways
- The basic characteristics of LANs, WANs, MANs, VLANs and VPNs.

Chapter 9 deals with the convergence of conventional PSTN networks and IP based internetworks, in particular the Internet. As a result of this convergence, 'voice over IP' is making major inroads into the telecommunications industry. This chapter will introduce the ITU-T H.323 standard for multimedia (audio, video and data) transmission and discuss the TCP/IP protocol suite sufficient for the understanding of the operation of this protocol.

Chapter 10 explains the basic operation of cellular wireless communication systems. The following wireless technologies are discussed:

- Analog cellular voice systems, in particular AMPS and N-AMPS
- Digital cellular voice systems, in particular D-AMPS (North American TDMA), CDMA and GSM
- Cellular data systems, in particular CDPD, GPRS and HDR
- 'Cordless' technologies, in particular CTS and DECT
- Personal communications service (PCS)
- Wireless applications protocol (WAP)
- Third generation (3G) mobile technologies.

Chapter 11 provides in-depth information about wireless LAN technologies. The following areas are discussed:

- IEEE 802.11, 802.11b, 802.11a
- Wireless LAN security issues
- Wireless personal area networks (WPAN)
- Blue tooth/IEEE 802.15.

1.4 Telecommunications standards

Telecommunications standards are essential to enable the global PSTN to function. It is clear that when a telephone call or data message originates in one country and terminates in another, both the sender and recipient need to understand each other's messages. This is most easily achieved by using standardized message formats. This enables a message to be successfully passed through a number of countries, as necessary, along the way.

This standardization is provided by two international organizations; the International Telecommunication Union (ITU), and the International Standardization Organisation (ISO). These are supplemented by many national standardization agencies.

The ITU provide recommendations, which serve as worldwide standards, although they are not legally binding. Prior to January 1993, their telecommunication recommendations were produced by the CCITT, the International Consultative Committee for Telephone and Telegraph, which has now been reorganized into the telecommunication standardization sector of the ITU. Their recommendations are denoted ITU-T. Similarly the International Consultative Committee for Radio (CCIR) handled the standardization of radio communications. This has now become the ITU radiocommunication sector and provides ITU-R recommendations.

The ISO has issued many important data communications standards. One of the most important is the open systems interconnection reference model, which we shall discuss later. Many national standards organizations are affiliated to ISO, including the American National Standards Institute (ANSI).

Some of the other important telecommunication standards organizations are:

- Electronics Industries Association (EIA)
- Telecommunication Industry Association (TIA)
- European Telecommunication Standardisation Institute (ETSI)
- Institute of Electrical and Electronic Engineers (IEEE)
- International Electrotechnical Commission (IEC).

Telecommunications standards are also developed by groups of manufacturers and users who formulate standards. These become ad hoc industry standards and may subsequently be incorporated in the recommendations of the international standards organizations. Some examples of these groups are the frame relay forum, the ADSL forum and the ATM forum.

2

Telecommunication basics

Objectives

The purpose of this chapter is to familiarize the reader with some of the basic telecommunications concepts used in this book. Where applicable, the user will be referred to the chapter dealing with that specific topic in greater depth.

2.1 Concepts

2.1.1 Signaling

In order to place a telephone call successfully, a signaling protocol has to convey information about the call through the telephone system in order to control, route and maintain the call. This information includes, for example, the number being called and signals representing specific conditions such as line free or subscriber unavailable. There are three different types of signals, described in detail in Chapter 4:

1. Addressing signals that represent the number being called
2. Alerting signals, indicating to the end-user that a call has arrived, and
3. Supervisory signals, indicating to the caller whether the line is free, the phone is ringing on the other side, etc., and to the exchange whether the caller's handset is off-hook or on-hook.

On older systems (prior to the mid-70s) this signaling was done by means of voltage levels and pulses or tones that represent the necessary information, using the same channel as the actual voice communication. This is referred to as in-band signaling, a process that is slow and wastes a significant amount of network capacity.

Because of the limitations of in-band signaling, common channel signaling (CCS) has been introduced. Here the signaling takes place on a separate signaling network. The current CCS ITU standard is Signaling System 7 (SS#7) and is described in Section 4.8.

2.1.2 Circuit

In telecommunications, a circuit is a physical electronic path that carries electronic information, be that voice or data, either in digital or analog format, between two points.

2.1.3 Channel

A channel refers to a 'logical' transmission path. For example, a particular radio station is allocated an FM channel centered on a specific frequency of 94.5 MHz. Using multiplexing techniques such as frequency division multiplexing (FDM), several transmission paths i.e. channels (based on different frequencies) can be created across a single medium and allocated to different users.

2.1.4 Line

A line is a telephone connection between a user and an exchange point set up by a telecommunications carrier.

2.1.5 Trunk

In telecommunications, the cable group that forms the primary path between two switching stations is known as a trunk. As such, it handles large volumes of traffic.

2.1.6 Bandwidth

The quantity of information a channel can convey in a given period is determined by its ability to handle the rate of change of the signal, i.e. its frequency. The frequency of an analog signal varies between a minimum and a maximum value and the difference between those two frequencies is the bandwidth of that signal.

The bandwidth of an analog channel is the difference between the highest and lowest frequencies that can be reliably transmitted over the channel. Bandwidth is normally specified in terms of those frequencies at which the signal has fallen to half the power (or 0.707 of the voltage) relative to the mid-band frequencies, referred to as –3dB points. In this case the bandwidth is known as the –3dB bandwidth (Figure 2.1).

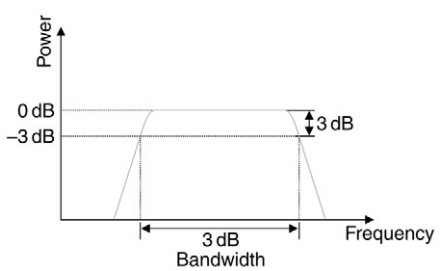

Figure 2.1
Channel bandwidth

Digital signals are made up of a large number of frequency components, but only those within the bandwidth of the channel will be able to be received. It follows that the larger the bandwidth of the channel, the higher the data transfer rate can be and more high frequency components of the digital signal can be transported, and so a more accurate reproduction of the transmitted signal can be received (Figure 2.2).