

APPENDIX A

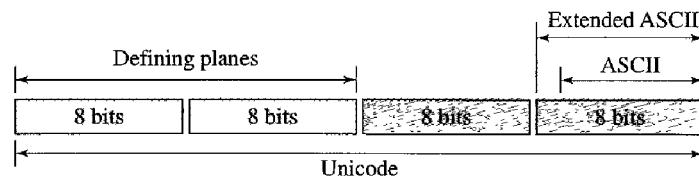
Unicode

Computers use numbers. They store characters by assigning a number for each one. The original coding system was called ASCII (American Standard Code for Information Interchange) and had 128 numbers (0 to 127) each stored as a 7-bit number. ASCII could satisfactorily handle lowercase and uppercase letters, digits, punctuation characters, and some control characters. An attempt was made to extend the ASCII character set to 8 bits. The new code, which was called Extended ASCII, was never internationally standardized.

To overcome the difficulties inherent in ASCII and Extended ASCII, the Unicode Consortium (a group of multilingual software manufacturers) created a universal encoding system to provide a comprehensive character set called **Unicode**.

Unicode was originally a 2-byte character set. Unicode version 3, however, is a 4-byte code and is fully compatible with ASCII and Extended ASCII. The ASCII set, which is now called *Basic Latin*, is Unicode with the upper 25 bits set to zero. Extended ASCII, which is now called Latin-1, is Unicode with the 24 upper bits set to zero. Figure A.1 shows how the different systems are compatible.

Figure A.1 *Unicode compatibility*



A.1 UNICODE

The prevalent code today is Unicode. Each character or symbol in this code is defined by a 32-bit number. The code can define up to 2^{32} (4,294,967,296) characters or symbols. The notation uses hexadecimal digits in the following format:

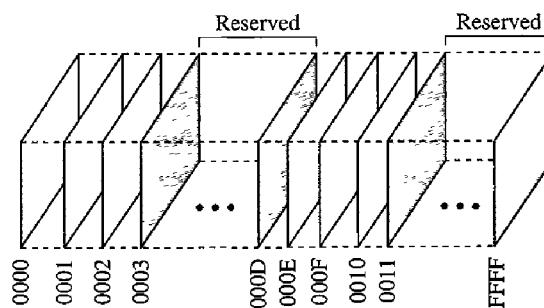
U-XXXXXX

Each X is a hexadecimal digit. Therefore, the numbering goes from U-00000000 to U-FFFFFFFFFF.

Planes

Unicode divides the available space codes into planes. The most significant 16 bits define the plane, which means we can have 65,535 planes. Each plane can define up to 65,536 character or symbols. Figure A.2 shows the structure of Unicode spaces and planes.

Figure A.2 *Unicode planes*



Plane 0000: Basic Multilingual Plane (BMP)

Plane 0001: Supplementary Multilingual Plane (SMP)

Plane 0002: Supplementary Ideographic Plane (SIP)

Plane 000E: Supplementary Special Plane (SSP)

Plane 000F: Private Use Plane (PUP)

Plane 0010: Private Use Plane (PUP)

Basic Multilingual Plane (BMP)

Plane 0000, the basic multilingual plane (BMP), is designed to be compatible with the previous 16-bit Unicode. The most significant 16 bits in this plane are all zeros. The codes are normally shown as U+XXXX with the understanding that XXXX defines only the least significant 16 bits. This plane mostly defines character sets in different languages with the exception of some codes used for control or other special characters. Table A.1 shows the main classification of codes in plane 0000.

Table A.1 *Unicode BMP*

Range	Description
A-Zone (Alphabetical Characters and Symbols)	
U+0000 to U+00FF	Basic Latin and Latin-1
U+0100 to U+01FF	Latin extended
U+0200 to U+02FF	IPA extension, and space modifier letters
U+0300 to U+03FF	Combining diacritical marks, Greek
U+0400 to U+04FF	Cyrillic
U+0500 to U+05FF	Armenian, Hebrew
U+0600 to U+06FF	Arabic

Table A.1 *Unicode BMP (continued)*

<i>Range</i>	<i>Description</i>
U+0700 to U+08FF	Reserved
U+0900 to U+09FF	Devanagari, Bengali
U+0A00 to U+0AFF	Gumukhi, Gujarati
U+0B00 to U+0BFF	Oriya, Tamil
U+0C00 to U+0CFF	Telugu, Kannada
U+0D00 to U+0DFF	Malayalam
U+0E00 to U+0EFF	Thai, Lao
U+0F00 to U+0FFF	Reserved
U+1000 to U+10FF	Georgian
U+1100 to U+11FF	Hangul Jamo
U+1200 to U+1DFF	Reserved
U+1E00 to U+1EFF	Latin extended additional
U+1F00 to U+1FFF	Greek extended
U+2000 to U+20FF	Punctuation, sub/superscripts, currency, marks
U+2100 to U+21FF	Letterlike symbols, number forms, arrows
U+2200 to U+22FF	Mathematical operations
U+2300 to U+23FF	Miscellaneous technical symbols
U+2400 to U+24FF	Control pictures, OCR, and enclosed alphanumeric
U+2500 to U+25FF	Box drawing, block drawing, and geometric shapes
U+2600 to U+26FF	Miscellaneous symbols
U+2700 to U+27FF	Dingbats and Braille patterns
U+2800 to U+2FFF	Reserved
U+3000 to U+30FF	CJK symbols and punctuation, hiragana, katakana
U+3100 to U+31FF	Bopomofo, hangul jambo, cjk miscellaneous
U+3200 to U+32FF	Enclosed CJK letters and months
U+3300 to U+33FF	CJK compatibility
U+3400 to U+4DFF	Hangul
I-Zone (Ideographic Characters)	
U+4E00 to U+9FFF	CJK unified ideographic
O-Zone (Open)	
U+A000 to U+DFFF	Reserved
R-Zone (Restricted Use)	
U+E000 to U+F8FF	Private use
U+F900 to U+FAFF	CJK compatibility ideographs
U+FB00 to U+FBFF	Arabic presentation form-A

Table A.1 *Unicode BMP (continued)*

<i>Range</i>	<i>Description</i>
U+FC00 to U+FDFF	Arabic presentation form-B
U+FE00 to U+FEFF	Half marks, small forms
U+FF00 to U+FFFF	Half-width and full-width forms

Supplementary Multilingual Plane (SMP)

Plane 0001, the supplementary multilingual plane (SMP), is designed to provide more codes for those multilingual characters that are not included in the BMP.

Supplementary Ideographic Plane (SIP)

Plane 0002, the supplementary ideographic plane (SIP), is designed to provide codes for ideographic symbols, symbols that primarily denote an idea (or meaning) in contrast to a sound (or pronunciation).

Supplementary Special Plane (SSP)

Plane 000E, the supplementary special plane (SSP), is used for special characters.

Private Use Planes (PUPs)

Planes 000F and 0010, private use planes (PUPs), are for private use.

A.2 ASCII

The American Standard Code for Information Interchange (ASCII) is a 7-bit code that was designed to provide code for 128 symbols, mostly in American English. Today, ASCII, or Basic Latin, is part of Unicode. It occupies the first 128 codes in Unicode (00000000 to 0000007F). Table A.2 contains the decimal, hexadecimal, and graphic codes (symbols) with an English interpretation, if appropriate. The codes in hexadecimal just define the two least significant digits in Unicode. To find the actual code, we prepend 000000 in hexadecimal to the code. The decimal code is just to show the integer value of each symbol when converted.

Table A.2 *ASCII Codes*

<i>Decimal</i>	<i>Hex</i>	<i>Symbol</i>	<i>Interpretation</i>
0	00	null	Null value
1	01	SOH	Start of heading
2	02	STX	Start of text
3	03	ETX	End of text
4	04	EOT	End of transmission

Table A.2 ASCII Codes (continued)

<i>Decimal</i>	<i>Hex</i>	<i>Symbol</i>	<i>Interpretation</i>
5	05	ENQ	Enquiry
6	06	ACK	Acknowledgment
7	07	BEL	Ring bell
8	08	BS	Backspace
9	09	HT	Horizontal tab
10	0A	LF	Line feed
11	0B	VT	Vertical tab
12	0C	FF	Form feed
13	0D	CR	Carriage return
14	0E	SO	Shift out
15	0F	SI	Shift in
16	10	DLE	Data link escape
17	11	DC1	Device control 1
18	12	DC2	Device control 2
19	13	DC3	Device control 3
20	14	DC4	Device control 4
21	15	NAK	Negative acknowledgment
22	16	SYN	Synchronous idle
23	17	ETB	End of transmission block
24	18	CAN	Cancel
25	19	EM	End of medium
26	1A	SUB	Substitute
27	1B	ESC	Escape
28	1C	FS	File separator
29	1D	GS	Group separator
30	1E	RS	Record separator
31	1F	US	Unit separator
32	20	SP	Space
33	21	!	
34	22	"	Double quote
35	23	#	
36	24	\$	
37	25	%	
38	26	&	
39	27	'	Apostrophe

1034 APPENDIX A UNICODE

Table A.2 ASCII Codes (continued)

<i>Decimal</i>	<i>Hex</i>	<i>Symbol</i>	<i>Interpretation</i>
40	28	(
41	29)	
42	2A	*	
43	2B	+	
44	2C	,	Comma
45	2D	-	Minus
46	2E	.	
47	2F	/	
48	30	0	
49	31	1	
50	32	2	
51	33	3	
52	34	4	
53	35	5	
54	36	6	
55	37	7	
56	38	8	
57	39	9	
58	3A	:	Colon
59	3B	;	Semicolon
60	3C	<	
61	3D	=	
62	3E	>	
63	3F	?	
64	40	@	
65	41	A	
66	42	B	
67	43	C	
68	44	D	
69	45	E	
70	46	F	
71	47	G	
72	48	H	
73	49	I	
74	4A	J	

Table A.2 ASCII Codes (continued)

<i>Decimal</i>	<i>Hex</i>	<i>Symbol</i>	<i>Interpretation</i>
75	4B	K	
76	4C	L	
77	4D	M	
78	4E	N	
79	4F	O	
80	50	P	
81	51	Q	
82	52	R	
83	53	S	
84	54	T	
85	55	U	
86	56	V	
87	57	W	
88	58	X	
89	59	Y	
90	5A	Z	
91	5B	[Open bracket
92	5C	\	Backslash
93	5D]	Close bracket
94	5E	^	Caret
95	5F	_	Underscore
96	60	`	Grave accent
97	61	a	
98	62	b	
99	63	c	
100	64	d	
101	65	e	
102	66	f	
103	67	g	
104	68	h	
105	69	i	
106	6A	j	
107	6B	k	
108	6C	l	
109	6D	m	

Table A.2 ASCII Codes (continued)

<i>Decimal</i>	<i>Hex</i>	<i>Symbol</i>	<i>Interpretation</i>
110	6E	n	
111	6F	o	
112	70	p	
113	71	q	
114	72	r	
115	73	s	
116	74	t	
117	75	u	
118	76	v	
119	77	w	
120	78	x	
121	79	y	
122	7A	z	
123	7B	{	Open brace
124	7C		Bar
125	7D	}	Close brace
126	7E	~	Tilde
127	7F	DEL	Delete

Some Properties of ASCII

ASCII has some interesting properties that we briefly mention here.

1. The first code (0) is the null character, which means the lack of any character.
2. The first 32 codes, 0 to 31, are control characters.
3. The space character, which is a printable character, is at position 32.
4. The uppercase letters start from 65 (A). The lowercase letters start from 97. When compared, uppercase letters are numerically smaller than lowercase letters. This means that in a sorted list based on ASCII values, the uppercase letters appear before the lowercase letters.
5. The uppercase and lowercase letters differ by only one bit in the 7-bit code. For example, character A is 1000001 (0x41) and character a is 1100001(0x61). The difference is in bit 6, which is 0 in uppercase letters and 1 in lowercase letters. If we know the code for one case, we can easily find the code for the other by adding or subtracting 32 in decimal (0x20 in hexadecimal), or we can just flip the sixth bit.
6. The uppercase letters are not immediately followed by lowercase letters. There are some punctuation characters in between.
7. Digits (0 to 9) start from 48 (0x3). This means that if you want to change a numeric character to its face value as an integer, you need to subtract 48.

APPENDIX B

Numbering Systems

We use different numbering systems: base 10 (decimal), base 2 (binary), base 8 (octal), base 16 (hexadecimal), base 256, and so on. All the numbering systems examined here are positional, meaning that the position of a symbol in relation to other symbols determines its value. Each symbol in a number has a position. The position traditionally starts from 0 and goes to $n - 1$, where n is the number of symbols. For example, in Figure B.1, the decimal number 14,782 has five symbols in positions 0 to 4.

Figure B.1 *Positions and symbols in a number*

Decimal number: 14,782					Symbols
1	4	7	8	2	
4	3	2	1	0	Positions

As we will see, the difference between different numbering systems is based on the *weight* assigned to each position.

B.1 BASE 10: DECIMAL

The base-10 or decimal system is the one most familiar to us in everyday life. All our terms for indicating countable quantities are based on it, and, in fact, when we speak of other numbering systems, we tend to refer to their quantities by their decimal equivalents. The term *decimal* is derived from the Latin stem *deci*, meaning 10. The decimal system uses 10 symbols to represent quantitative values: 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9.

Decimal numbers use 10 symbols: 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9.

Weights

In the decimal system, each weight equals 10 raised to the power of its position. The weight of the symbol at position 0 is 10^0 (1); the weight of the symbol at position 1 is 10^1 (10); and so on.

B.2 BASE 2: BINARY

The binary number system provides the basis for all computer operations. Computers work by turning electric current on and off. The binary system uses two symbols, 0 and 1, so it corresponds naturally to a two-state device, such as a switch, with 0 to represent the off state and 1 to represent the on state. The word *binary* derives from the Latin stem *bi*, meaning 2.

Binary numbers use two symbols: 0 and 1.

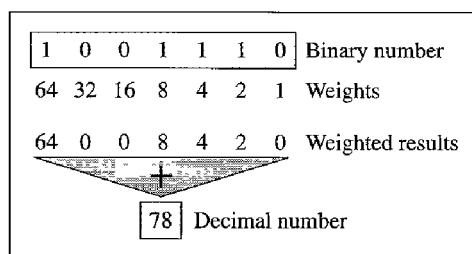
Weights

In the binary system, each weight equals 2 raised to the power of its position. The weight of the symbol at position 0 is 2^0 (1); the weight of the symbol at position 1 is 2^1 (2); and so on.

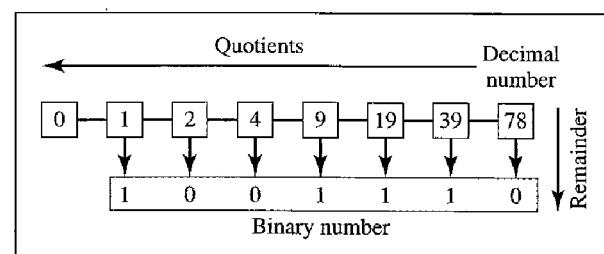
Conversion

Now let us see how we can convert binary to decimal and decimal to binary. Figure B.2 show the two processes.

Figure B.2 *Binary-to-decimal and decimal-to-binary conversion*



a. Binary to decimal



b. Decimal to binary

To convert a binary number to decimal, we use the weights. We multiply each symbol by its weight and add all the weighted results. Figure B.2 shows how we can change binary 1001110 to its decimal equivalent 78.

A simple division trick gives us a convenient way to convert a decimal number to its binary equivalent, as shown in Figure B.2. To convert a number from decimal to binary, divide the number by 2 and write down the remainder (1 or 0). That remainder is the least significant binary digit. Now, divide the quotient of that division by 2 and

write down the new remainder in the second position. Repeat this process until the quotient becomes zero.

B.3 BASE 16: HEXADECIMAL

Another system used in this text is base 16. The term *hexadecimal* is derived from the Greek term *hexadec*, meaning 16. The hexadecimal number system is convenient for identifying a large binary number in a shorter form. The hexadecimal system uses 16 symbols: 0, 1, . . . , 9, A, B, C, D, E, and F. The hexadecimal system uses the same first 10 symbols as the decimal system, but instead of using 10, 11, 12, 13, 14, and 15, it uses A, B, C, D, E, and F. This prevents any confusion between two adjacent symbols.

Hexadecimal numbers use 16 symbols: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, and F

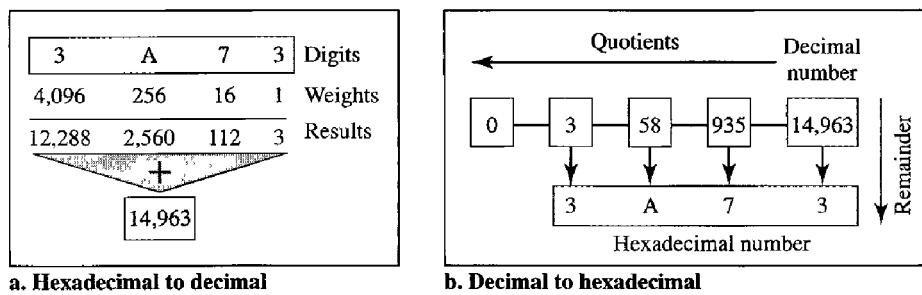
Weights

In the hexadecimal system, each weight equals 16 raised to the power of its position. The weight of the symbol at position 0 is 16^0 (1); the weight of the symbol at position 1 is 16^1 (16); and so on.

Conversion

Now let us see how we can convert hexadecimal to decimal and decimal to hexadecimal. Figure B.3 show the two processes.

Figure B.3 Hexadecimal-to-decimal and decimal-to-hexadecimal conversion



To convert a hexadecimal number to decimal, we use the weights. We multiply each symbol by its weight and add all the weighted results. Figure B.3 shows how hexadecimal 0x3A73 is transformed to its decimal equivalent 14,963.

We use the same trick we used for changing decimal to binary to transform a decimal to hexadecimal. The only difference is that we divide the number by 16 instead of 2. The figure also shows how 14,963 in decimal is converted to hexadecimal 0x3A73.

A Comparison

Table B.1 shows how systems represent the decimal numbers 0 through 15. As you can see, decimal 13 is equivalent to binary 1101, which is equivalent to hexadecimal D.

Table B.1 *Comparison of three systems*

Decimal	Binary	Hexadecimal
0	0	0
1	1	1
2	10	2
3	11	3
4	100	4
5	101	5
6	110	6
7	111	7
8	1000	8
9	1001	9
10	1010	A
11	1011	B
12	1100	C
13	1101	D
14	1110	E
15	1111	F

B.4 BASE 256: IP ADDRESSES

One numbering system that is used in the Internet is base 256. IPv4 addresses use this base to represent an address in dotted decimal notation. When we define an IPv4 address as 131.32.7.8, we are using a base-256 number. In this base, we could have used 256 unique symbols, but remembering that many symbols and their values is burdensome. The designers of the IPv4 address decided to use decimal numbers 0 to 255 as symbols and to distinguish between the symbols, a *dot* is used. The dot is used to separate the symbols; it marks the boundary between the positions. For example, the IPv4 address 131.32.7.8 is made of the four symbols 8, 7, 32, and 131 at positions 0, 1, 2, and 3, respectively.

IPv4 addresses use the base-256 numbering system.

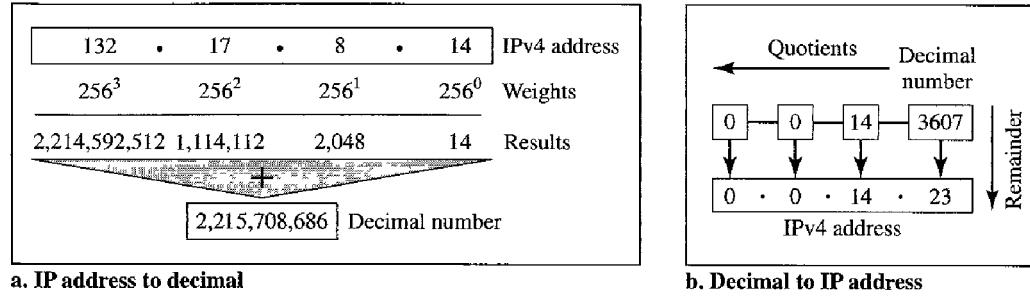
**The symbols in IPv4 are decimal numbers between 0 and 255;
the separator is a dot.**

Weights

In base 256, each weight equals 256 raised to the power of its position. The weight of the symbol at position 0 is 256^0 (1); the weight of the symbol at position 1 is 256^1 (256); and so on.

Conversion

Now let us see how we can convert hexadecimal to decimal and decimal to hexadecimal. Figure B.4 show the two processes.

Figure B.4 IPv4 address to decimal transformation

To convert an IPv4 address to decimal, we use the weights. We multiply each symbol by its weight and add all the weighted results. The figure shows how the IPv4 address 131.32.7.8 is transformed to its decimal equivalent.

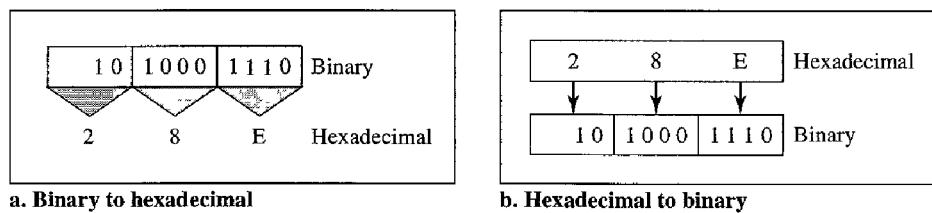
We use the same trick we used for changing decimal to binary to transform a decimal to an IPv4 address. The only difference is that we divide the number by 256 instead of 2. However, we need to remember that the IPv4 address has four positions. This means that when we are dealing with an IPv4 address, we must stop after we have found four values. Figure B.4 shows an example for an IPv4 address.

B.5 OTHER CONVERSATIONS

There are other transformations such as base 2 to base 16 or base 16 to base 256. It is easy to use base 10 as the intermediate system. In other words, to change a number from binary to hexadecimal we first change the binary to decimal and then change the decimal to hexadecimal. We discuss some easy methods for common transformations.

Binary and Hexadecimal

There is a simple way to convert binary to hexadecimal and vice versa as shown in Figure B.5.

Figure B.5 Transformation from binary to hexadecimal

To change a number from binary to hexadecimal, we group the binary digits from the right by fours. Then we convert each 4-bit group to its hexadecimal equivalent,

1042 APPENDIX B NUMBERING SYSTEMS

using Table B.1. In the figure, we convert binary 1010001110 to hexadecimal 0x28E. To change a hexadecimal number to binary, we convert each hexadecimal digit to its equivalent binary number, using Table B.1, and concatenate the results. In Figure B.5 we convert hexadecimal 0x28E to binary.

Base 256 and Binary

To convert a base 256 number to binary, we first need to convert the number in each position to an 8-bit binary group and then concatenate the groups. To convert from binary to base 256, we need to divide the binary number into groups of 8 bits, convert each group to decimal, and then insert separators (dots) between the decimal numbers.

APPENDIX C

Mathematical Review

In this appendix, we review some mathematical concepts that may help you to better understand the topics covered in the book. Perhaps the most important concept in data communications is signals and their representation. We start with a brief review of trigonometric functions, as discussed in a typical precalculus book. We then briefly discuss Fourier analysis, which provides a tool for the transformation between the time and frequency domains. We finally give a brief treatment of exponential and logarithmic functions.

C.1 TRIGONOMETRIC FUNCTIONS

Let us briefly discuss some characteristics of the trigonometric functions as used in the book.

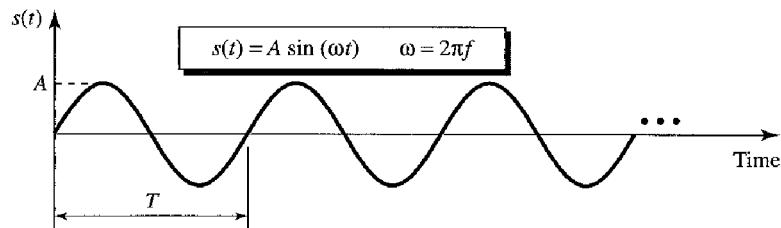
Sine Wave

We can mathematically describe a sine wave as

$$s(t) = A \sin(2\pi ft) = A \sin\left(\frac{2\pi}{T}t\right)$$

where s is the instantaneous amplitude, A is the peak amplitude, f is the frequency, and T is the period (phase will be discussed later). Figure C.1 shows a sine wave.

Figure C.1 A sine wave



Note that the value of $2\pi f$ is called the radian frequency and written as ω (omega), which means that a sine function can be written as $s(t) = A \sin(\omega t)$.

1044 APPENDIX C MATHEMATICAL REVIEW

Example C.1

Find the peak value, frequency, and period of the following sine waves.

- $s(t) = 5 \sin(10\pi t)$
- $s(t) = \sin(10t)$

Solution

- Peak amplitude: $A = 5$
Frequency: $10\pi = 2\pi f$, so $f = 5$
Period: $T = 1/f = 1/5$ s
- Peak amplitude: $A = 1$
Frequency: $10 = 2\pi f$, so $f = 10/(2\pi) = 1.60$
Period: $T = 1/f = 1/1.60 = 0.628$ s

Example C.2

Show the mathematical representation of a sine wave with a peak amplitude of 2 and a frequency of 1000 Hz.

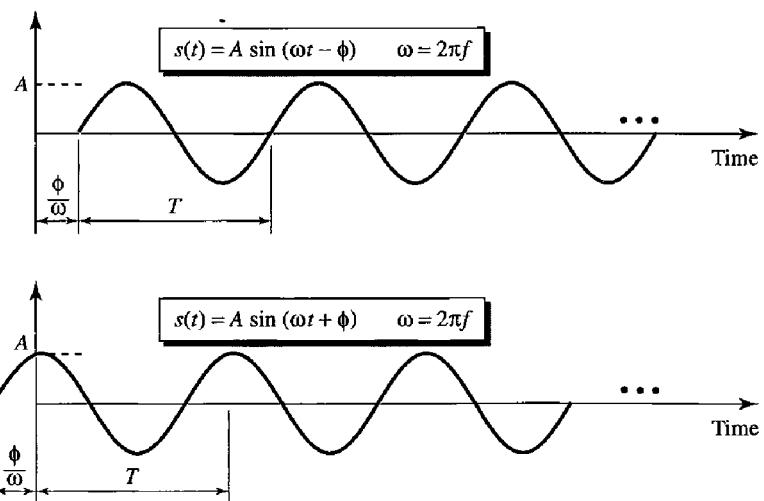
Solution

The mathematical representation is $s(t) = 2 \sin(2000\pi t)$.

Horizontal Shifting (Phase)

All the sine functions we discussed so far have an amplitude of value 0 at the origin. What if we shift the signal to the left or to the right? Figure C.2 shows two simple sine waves, one shifted to the right and one to the left.

Figure C.2 Two horizontally shifted sine waves



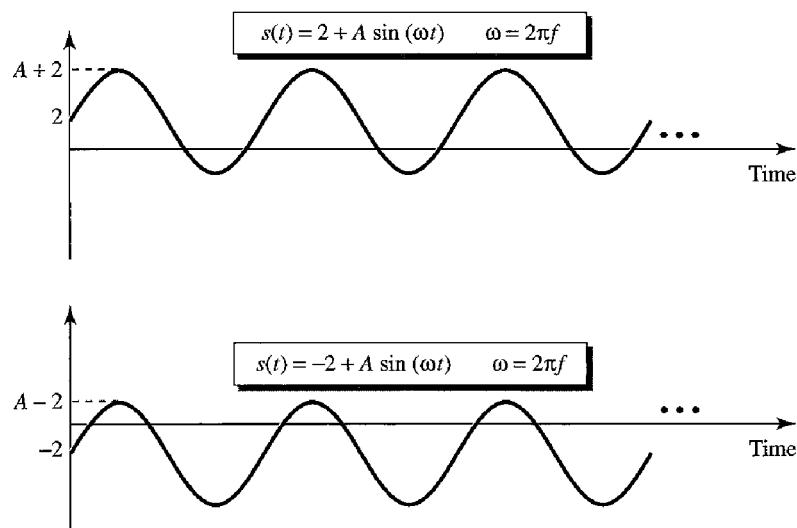
When a signal is shifted to the left or right, its first zero crossing will be at a point in time other than the origin. To show this, we need to add or subtract another constant to ωt , as shown in the figure.

Shifting a sine wave to the left or right is a positive or negative shift, respectively.

Vertical Shifting

When a sine wave is shifted vertically, a constant is added to the instantaneous amplitude of the signal. For example, if we shift a sine wave 2 units of amplitude upward, the signal becomes $s(t) = 2 + \sin(\omega t)$; if we shift it 2 units of amplitude downward, we have $s(t) = -2 + \sin(\omega t)$. Figure C.3 shows the idea.

Figure C.3 Vertical shifting of sine waves



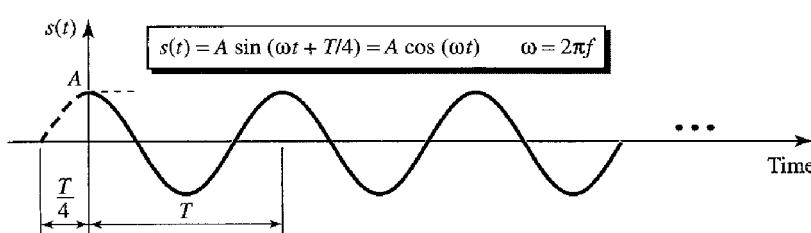
Cosine Wave

If we shift a sine wave $T/2$ to the left, we get what is called a cosine wave (\cos).

$$A \sin(\omega t + \pi/2) = A \cos(\omega t)$$

Figure C.4 shows a cosine wave.

Figure C.4 A cosine wave



Other Trigonometric Functions

There are many trigonometric functions; two of the more common are $\tan(\omega t)$ and $\cot(\omega t)$. They are defined as $\tan(\omega t) = \sin(\omega t)/\cos(\omega t)$ and $\cot(\omega t) = \cos(\omega t)/\sin(\omega t)$. Note that tan and cot are the inverse of each other.

Trigonometric Identities

There are several identities between trigonometric functions that we sometimes need to know. Table C.1 gives these identities for reference. Other identities can be easily derived from these.

Table C.1 *Some trigonometric identities*

Name	Formula
Pythagorean	$\sin^2 x + \cos^2 x = 1$
Even/odd	$\sin(-x) = -\sin(x)$ $\cos(-x) = \cos(x)$
Sum	$\sin(x+y) = \sin(x)\cos(y) + \cos(x)\sin(y)$ $\cos(x+y) = \cos(x)\cos(y) - \sin(x)\sin(y)$
Difference	$\sin(x-y) = \sin(x)\cos(y) - \cos(x)\sin(y)$ $\cos(x-y) = \cos(x)\cos(y) + \sin(x)\sin(y)$
Product to sum	$\sin(x)\sin(y) = 1/2 [\cos(x-y) - \cos(x+y)]$ $\cos(x)\cos(y) = 1/2 [\cos(x-y) + \cos(x+y)]$ $\sin(x)\cos(y) = 1/2 [\sin(x+y) + \sin(x-y)]$ $\cos(x)\sin(y) = 1/2 [\sin(x+y) - \sin(x-y)]$

C.2 FOURIER ANALYSIS

Fourier analysis is a tool that changes a time-domain signal to a frequency-domain signal and vice versa.

Fourier Series

Fourier proved that a composite periodic signal with period T (frequency f) can be decomposed into a series of sine and cosine functions in which each function is an integral harmonic of the fundamental frequency f of the composite signal. The result is called the **Fourier series**. In other words, we can write a composite signal as shown in Figure C.5. Using the series, we can decompose any periodic signal into its harmonics. Note that A_0 is the average value of the signal over a period, A_n is the coefficient of the n th cosine component, and B_n is the coefficient of the n th sine component.

Example C.3

Let us show the components of a square wave signal as seen in Figure C.6. The figure also shows the time domain and the frequency domain. According to the figure, such a square wave signal has only A_n coefficients. Note also that the value of $A_0 = 0$ because the average value of the signal is 0; it is oscillating above and below the time axis. The frequency domain of the signal is discrete;

Figure C.5 Fourier series and coefficients of terms

Fourier series

$$s(t) = A_0 + \sum_{n=1}^{\infty} A_n \sin(2\pi nft) + \sum_{n=1}^{\infty} B_n \cos(2\pi nft)$$

$$A_0 = \frac{1}{T} \int_0^T s(t) dt$$

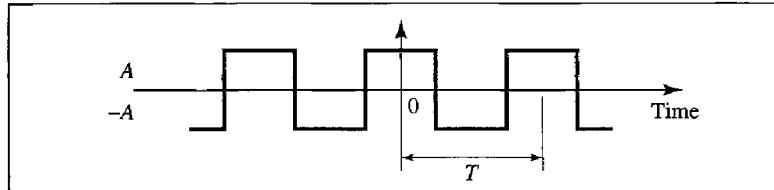
$$A_n = \frac{2}{T} \int_0^T s(t) \cos(2\pi nft) dt$$

$$B_n = \frac{2}{T} \int_0^T s(t) \sin(2\pi nft) dt$$

Coefficients

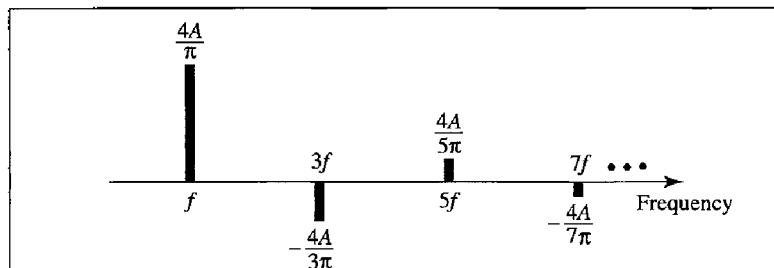
Fourier series**Time domain: periodic****Frequency domain: discrete**

only odd harmonics are present and the amplitudes are alternatively positive and negative. A very important point is that the amplitude of the harmonics approaches zero as we move toward infinity. Something which is not shown in the figure is the phase. However, we know that all components are cosine waves, which means that each has a phase of 90°.

Figure C.6 Finding the Fourier series of a periodic square function**Time domain**

$$A_0 = 0 \quad A_n = \begin{cases} \frac{4A}{n\pi} & \text{for } n = 1, 3, 5, 9, \dots \\ -\frac{4A}{n\pi} & \text{for } n = 2, 4, 6, 8, \dots \end{cases} \quad B_n = 0$$

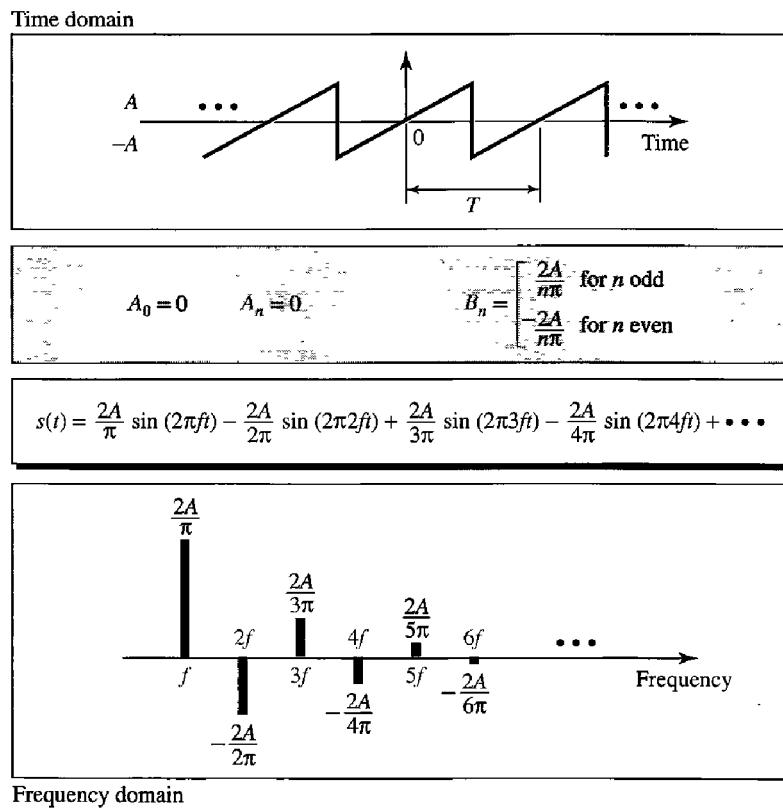
$$s(t) = \frac{4A}{\pi} \cos(2\pi ft) - \frac{4A}{3\pi} \cos(2\pi 3ft) + \frac{4A}{5\pi} \cos(2\pi 5ft) - \frac{4A}{7\pi} \cos(2\pi 7ft) + \dots$$

**Frequency domain**

Example C.4

Now let us show the components of a sawtooth signal as seen in Figure C.7. This time, we have only B_n components (sine waves). The frequency spectrum, however, is denser; we have all harmonics ($f, 2f, 3f, \dots$). A point which is not clear from the diagram is the phase. All components are sine waves, which means each component has a phase of 0° .

Figure C.7 Finding the Fourier series for a sawtooth signal

**Fourier Transform**

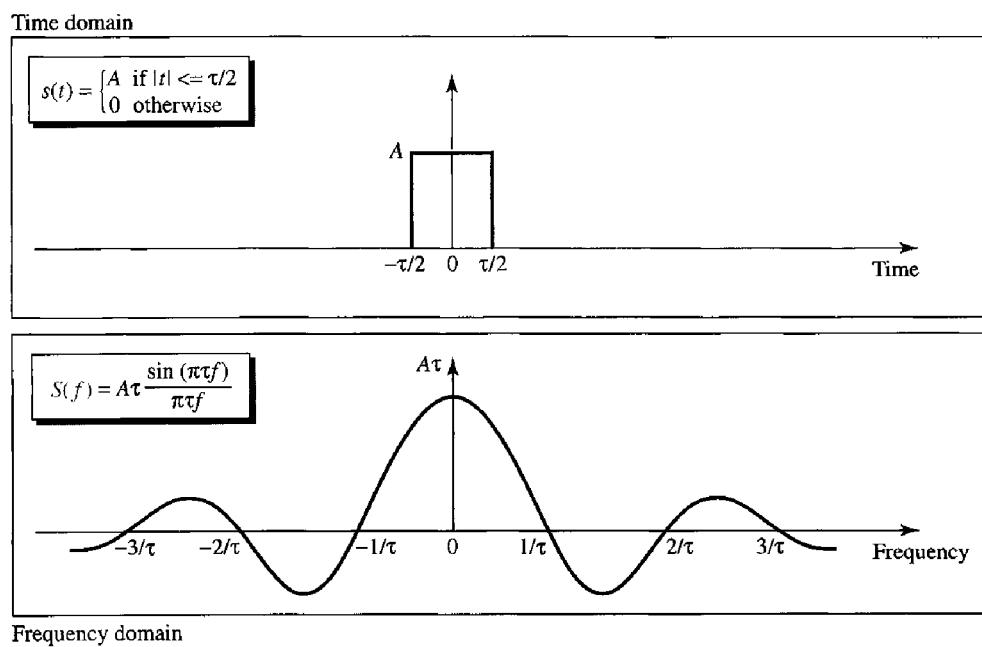
While the Fourier series gives the discrete frequency domain of a periodic signal, the **Fourier transform** gives the continuous frequency domain of a nonperiodic signal. Figure C.8 shows how we can create a continuous frequency domain from a nonperiodic time-domain function and vice versa.

Figure C.8 Fourier transform and inverse Fourier transform

$S(f) = \int_{-\infty}^{\infty} s(t) e^{-j2\pi ft} dt$	$s(t) = \int_{-\infty}^{\infty} S(f) e^{j2\pi ft} dt$
Fourier transform	Inverse Fourier transform

Fourier transform**Time domain: nonperiodic****Frequency domain: continuous****Example C.5**

Figure C.9 shows the time and frequency domains of one single square pulse. The time domain is between $-\tau/2$ and $\tau/2$; the frequency domain is a continuous function that stretches from negative infinity to positive infinity. Unlike the previous examples, the frequency domain is continuous; all frequencies are there, not just the integral ones.

Figure C.9 Finding the Fourier transform of a square pulse**Time-Limited and Band-Limited Signals**

Two very interesting concepts related to the Fourier transform are the time-limited and band-limited signals. A **time-limited** signal is a signal for which the amplitude of $s(t)$ is nonzero only during a period of time; the amplitude is zero everywhere else. A **band-limited** signal, on the other hand, is the signal for which the amplitude of $S(f)$ is nonzero only for a range of frequencies; the amplitude is zero everywhere else. A band-limited signal plays a very important role in the sampling theorem and Nyquist frequency because the corresponding time domain can be represented as a series of samples.

Time-limited signal: $s(t) = 0$ for $|t| \leq T$

Band-limited signal: $S(f) = 0$ for $|f| \leq B$

C.3 EXPONENT AND LOGARITHM

In solving networking problems, we often need to know how to handle exponential and logarithmic functions. This section briefly reviews these two concepts.

Exponential Function

The exponential function with **base a** is defined as

$$y = a^x$$

If x is an integer (integral value), we can easily calculate the value of y by multiplying the value of a by itself x times.

Example C.6

Calculate the value of the following exponential functions.

- a. $y = 3^2$
- b. $y = 5.2^6$

Solution

- a. $y = 3 \times 3 = 9$
- b. $y = 5.2 \times 5.2 \times 5.2 \times 5.2 \times 5.2 \times 5.2 = 19,770.609664$

If x is not integer, we need to use a calculator.

Example C.7

Calculate the value of the following exponential functions.

- a. $y = 3^{2.2}$
- b. $y = 5.2^{6.3}$

Solution

- a. $y = 11.212$ (approximately)
- b. $y = 32,424.60$ (approximately)

Natural Base

One very common base used in science and mathematics is the **natural base e** , which has the value 2.71828183. . . . Most calculators show this function as e^x , which can be calculated easily by entering only the value of the exponent.

Example C.8

Calculate the value of the following exponential functions.

- a. $y = e^4$
- b. $y = e^{6.3}$

Solution

- a. $y = 54.56$ (approximately)
- b. $y = 544.57$ (approximately)

Properties of the Exponential Function

Exponential functions have several properties; some are useful to us in this text:

First:	$y = a^0 = 1$
Second:	$y = a^1 = a$
Third:	$y = a^{-x} = \frac{1}{a^x}$

Example C.9

The third property is useful to us because we can calculate the value of an exponential function with a negative value. We first calculate the positive value and we then invert the result.

- a. $y = e^{-4}$
- b. $y = e^{-6.3}$

Solution

- a. $y = 1/54.56 = 0.0183$
- b. $y = 1/544.57 = 0.00183$

Logarithmic Function

A logarithmic function is the inverse of an exponential function, as shown below. Just as in the exponential function, a is called the base of the logarithmic function:

$$y = a^x \iff x = \log_a y$$

In other words, if x is given, we can calculate y by using the exponential function; if y is given, we can calculate x by using the logarithmic function.

Exponential and logarithmic functions are the inverse of each other.

Example C.10

Calculate the value of the following logarithmic functions.

- a. $x = \log_3 9$
- b. $x = \log_2 16$

Solution

We have not yet shown how to calculate the log function in different bases, but we can solve this problem intuitively.

- a. Because $3^2 = 9$, we can say that $\log_3 9 = 2$, using the fact that the two functions are the inverse of each other.
- b. Because $2^4 = 16$, we can say that $\log_2 16 = 4$ by using the previous fact.

Two Common Bases

The two common bases for logarithmic functions, those that can be handled by a calculator, are base e and base 10. The logarithm in base e is normally shown as ln (natural logarithm); the logarithm in base 10 is normally shown as log (omitting the base).

1052 APPENDIX C MATHEMATICAL REVIEW

Example C.11

Calculate the value of the following logarithmic functions.

- $x = \log 233$
- $x = \ln 45$

Solution

For these two bases we can use a calculator.

- $x = \log 233 = 2.367$
- $x = \ln 45 = 3.81$

Base Transformation

We often need to find the value of a logarithmic function in a base other than e or 10. If the available calculator cannot give the result in our desired base, we can use a very fundamental property of the logarithm, base transformation, as shown:

$$\log_a y = \frac{\log_b y}{\log_b a}$$

Note that the right-hand side is two log functions with base b , which is different from the base a at the left-hand side. This means that we can choose a base that is available in our calculator (base b) and find the log of a base that is not available (base a).

Example C.12

Calculate the value of the following logarithmic functions.

- $x = \log_3 810$
- $x = \log_5 600$

Solution

These two bases, 3 and 5, are not available on a calculator, but we can use base 10 which is available.

$$\begin{aligned} \text{a. } x = \log_3 810 &= \frac{\log_{10} 810}{\log_{10} 3} = \frac{2.908}{0.477} = 6.095 \\ \text{b. } x = \log_5 600 &= \frac{\log_{10} 600}{\log_{10} 5} = \frac{2.778}{0.699} = 3.975 \end{aligned}$$

Properties of Logarithmic Functions

Like an exponential function, a logarithmic function has some properties that are useful in simplifying the calculation of a log function.

First:	$\log_a 1 = 0$	Fourth:	$\log_a (x \times y) = \log_a x + \log_a y$
Second:	$\log_a a = 1$	Fifth:	$\log_a \frac{x}{y} = \log_a x - \log_a y$
Third:	$\log_a \frac{1}{x} = -\log_a x$	Sixth:	$\log_a x^y = y \times \log_a x$

Example C.13

Calculate the value of the following logarithmic functions.

- a. $x = \log_3 1$
- b. $x = \log_3 3$
- c. $x = \log_{10} (1/10)$
- d. $\log_a (x \times y)$ if we know that $\log_a x = 2$ and $\log_a y = 3$
- e. $\log_2 (1024)$ without using a calculator

Solution

We use the property of log functions to solve the problems.

- a. $x = \log_3 1 = 0$
- b. $x = \log_3 3 = 1$
- c. $x = \log_{10} (1/10) = \log_{10} 10^{-1} = -\log_{10} 10 = -1$
- d. $\log_a (x \times y) = \log_a x + \log_a y = 2 + 3 = 5$
- e. $\log_2 (1024) = \log_2 (2^{10}) = 10 \log_2 2 = 10 \times 1 = 10$

APPENDIX D

8B/6T Code

This appendix is a tabulation of 8B/6T code pairs. The 8-bit data are shown in hexadecimal format. The 6T code is shown as + (positive signal), – (negative signal), and 0 (lack of signal) notation.

Table D.1 8B/6T code

Data	Code	Data	Code	Data	Code	Data	Code
00	--00--	20	-++-00	40	-00+0+	60	0++0-0
01	0--+--0	21	+00+--	41	0-00++	61	+0+-00
02	0-+0--	22	-+0-++	42	0-0+0+	62	+0+0-0
03	0-++0-	23	+--0-++	43	0-0++0	63	+0+00-
04	-+0+0-	24	+--0+00	44	-00++0	64	0++00-
05	+0---+0	25	-+0+00	45	00-0++	65	++0-00
06	+0-0--	26	+00-00	46	00-+0+	66	++00-0
07	+0-+0-	27	-++++-	47	00-++0	67	++000-
08	-+00+-	28	0++-0-	48	00+000	68	0++-+-
09	0-++-0	29	+0+0--	49	++-000	69	+0++--
0A	0-+0+-	2A	+0+-0-	4A	++000	6A	+0+-+-
0B	0-+-0+	2B	+0+-+0	4B	-++000	6B	+0+---
0C	-+0-0+	2C	0+---0	4C	0+-000	6C	0+---+
0D	+0-+-0	2D	++00--	4D	+0-000	6D	++0+--
0E	+0-0+-	2E	++0-0-	4E	0-+000	6E	++0-+-
0F	+0--0+	2F	++0--0	4F	-0+000	6F	++0---
10	0---+0+	30	+--00-	50	++-+0+	70	000++-
11	-0-0++	31	0+---+0	51	-+-0++	71	000++-
12	-0-+0+	32	0+-0-+	52	-++-0+	72	000-++
13	-0-++0	33	0+-+0-	53	-++-+0	73	000+00

Table D.1 8B/6T code (*continued*)

<i>Data</i>	<i>Code</i>	<i>Data</i>	<i>Code</i>	<i>Data</i>	<i>Code</i>	<i>Data</i>	<i>Code</i>
14	0---++0	34	+--0+0-	54	+---++0	74	000+0-
15	--00++	35	-0+-+0	55	---+0++	75	000+-0
16	--0+0+	36	-0+0-+	56	---++0+	76	000-0+
17	--0++0	37	-0++0-	57	---+++0	77	000-+0
18	-+0-+0	38	+--0+-	58	--0+++	78	++++-0
19	+--0-+0	39	0+-+--0	59	-0-----	79	++++-0-
1A	-+--+0	3A	0+-0+-	5A	0-----+	7A	+++-0--
1B	+00-+0	3B	0+---0+	5B	0---0++	7B	0++0--
1C	+00+-0	3C	+--0-0+	5C	++--0++	7C	-00-++
1D	-+---0	3D	-0++-0	5D	-000++	7D	-00+00
1E	+--0+-0	3E	-0+0+-	5E	0+++--	7E	+-+---++
1F	-+0+-0	3F	-0+-0+	5F	0++-00	7F	+-+-+00
80	-00+--	A0	-++0-0	C0	-+0+-+	E0	-++0-+
81	0-0-++	A1	+--+00	C1	0-+---	E1	++-+0
82	0-0+--	A2	+--0-0	C2	0-+---	E2	++-+0-+
83	0-0++-	A3	+--00-	C3	0-+---	E3	++-+0-
84	-00+--	A4	-++00-	C4	-+0+--	E4	-++-0-
85	00----	A5	++--00	C5	+0---+	E5	++--+0
86	00-+--	A6	++-0-0	C6	+0-+--	E6	++-0-+
87	00-++-	A7	++-00-	C7	+0-+--	E7	++-+0-
88	-000+0	A8	-++-+-	C8	-+00+0	E8	-++0+-
89	0-0+00	A9	+---+-	C9	0-++00	E9	+---+0
8A	0-00+0	AA	+---+-	CA	0-+0+0	EA	+--0+-
8B	0-000+	AB	+----+	CB	0-+00+	EB	+--+-0+
8C	-0000+	AC	-+----	CC	-+000+	EC	-++-0+
8D	00-+00	AD	++-+--	CD	+0-+00	ED	++-+-0
8E	00-0+0	AE	++--+-	CE	+0-0+0	EE	++-0+-
8F	00-00+	AF	++----	CF	+0-00+	EF	++--0+
90	++-+--	B0	+000-0	D0	+--0+-	F0	+000-+
91	-+---++	B1	0+0-00	D1	0+---+	F1	0+0-+0
92	-+---+-	B2	0+00-0	D2	0+---+	F2	0+00-+
93	-+---+-	B3	0+000-	D3	0+---+	F3	0+0+0-
94	++-+--	B4	+0000-	D4	+--0+-	F4	+00+0-

Table D.1 8B/6T code (*continued*)

<i>Data</i>	<i>Code</i>	<i>Data</i>	<i>Code</i>	<i>Data</i>	<i>Code</i>	<i>Data</i>	<i>Code</i>
95	--- -++	B5	00 + -00	D5	-0 + -++	F5	00 +- +0
96	--- ++-	B6	00 +0 -0	D6	-0 ++ -+	F6	00 +0 --
97	--- ++-	B7	00 +00 -	D7	-0 +++ -	F7	00 ++0 -
98	+- -0 +0	B8	+00 -+ -	D8	+ -00 +0	F8	+000 + -
99	-+ -+ 00	B9	0+0 +--	D9	0+ -+ 00	F9	0+0 + -0
9A	-+ -0 +0	BA	0+0 -+ -	DA	0+ -0 +0	FA	0+00 + -
9B	-+ -00 +	BB	0+0 -+ -	DB	0+ -00 +	FB	0+0 -0 +
9C	+ -+ 00 +	BC	+00 -+ -	DC	+ -000 +	FC	+00 -0 +
9D	-+ -+ 00	BD	00 + +--	DD	-0 ++ 00	FD	00 ++ -0
9E	-+ -+ 0 +0	BE	00 + -+ -	DE	-0 +0 +0	FE	00 +0 + -
9F	-+ -+ 00 +	BF	00 + -+ -	DF	-0 +00 +	FF	00 + -0 +

APPENDIX E

Telephone History

In Chapter 9, we discussed telephone networks. In this appendix, we briefly review the history of telephone networks. The history in the United States can be divided into three eras: prior to 1984, between 1984 and 1996, and after 1996.

Before 1984

Before 1984, almost all local and long-distance services were provided by the AT&T Bell System. In 1970, the U.S. government, believing that the Bell System was monopolizing the telephone service industry, sued the company. The verdict was in favor of the government and resulted in a document called the Modified Final Judgment (MFJ). Beginning on January 1, 1984, AT&T was broken into AT&T Long Lines, 23 Bell Operating Companies (BOCs), and others. The 23 BOCs were grouped to make several Regional Bell Operating Companies (RBOCs). This landmark event, the AT&T divestiture of 1984, was beneficial to customers of telephone services. Telephone rates were lowered.

Between 1984 and 1996

The divestiture divided the country into more than 200 LATAs; some companies were allowed to provide services inside a LATA (LECs), and others were allowed to provide services between LATAs (IXCs). Competition, particularly between long-distance carriers, increased as new companies were formed. However, no LEC could provide long-distance services, and no IXC could provide local services.

After 1996

Another major change in telecommunications occurred in 1996. The Telecommunications Act of 1996 combined the different services provided by different companies under the umbrella of telecommunication services; this included local services, long-distance voice and data services, video services, and so on. In addition, the act allowed any company to provide any of these services at the local and long-distance levels. In other words, a common carrier company provides services both inside the LATA and between the LATAs. However, to prevent the recabling of residents, the carriers that were given intra-LATA services (ILECs) continued to provide the main services; the new competitors (CLECs) provided other services.

APPENDIX F

Contact Addresses

The following is a list of contact addresses for various organizations mentioned in the text.

ATM Forum

Presidio of San Francisco
P.O. Box 29920 (mail)
572B Ruger Street (surface)
San Francisco, CA 94129-0920
Telephone: 415 561-6275
E-mail: info@atmforum.com
www.atmforum.com

Federal Communications Commission (FCC)

445 12th Street S.W.
Washington, DC 20554
Telephone: 1-888-225-5322
E-mail: fccinfo@fcc.gov
www.fcc.gov

Institute of Electrical and Electronics Engineers (IEEE)

Operations Center
445 Hoes Lane
Piscataway, NJ 08854-1331
Telephone: 732 981-0060
www.ieee.org

1062 APPENDIX F CONTACT ADDRESSES

- International Organization for Standardization (ISO)**
1, rue de Varembe
Caisse Postale 56
CH-1211 Geneve 20
Switzerland
Telephone: 41 22 749 0111
E-mail: central@iso.ch
www.iso.org
- International Telecommunication Union (ITU)**
Place des Nations
CH-1211 Geneva 20
Switzerland
Telephone: 41 22 730 5852
E-mail: tsbmail@itu.int
www.itu.int/home
- Internet Architecture Board (IAB)**
E-mail: IAB@isi.edu
www.iab.org
- Internet Corporation for Assigned Names and Numbers (ICANN)**
4676 Admiralty Way, Suite 330
Marina del Rey, CA 90292-6601
Telephone: 310 823-9358
E-mail: icann@icann.org
www.icann.org
- Internet Engineering Steering Group (IESG)**
E-mail: iesg@ietf.org
www.ietf.org/iesg.html
- Internet Engineering Task Force (IETF)**
E-mail: ietf-infor@ietf.org
www.ietf.org
- Internet Research Task Force (IRTF)**
E-mail: irtf-chair@ietf.org
www.irtf.org
- Internet Society (ISOC)**
1775 Weihe Avenue, Suite 102
Reston, VA 20190-5108
Telephone: 703.326-9880
E-mail: info@isoc.org
www.isoc.org

APPENDIX G

RFCs

In Table G.1, we list alphabetically by protocol the RFCs that are directly related to the material in this text. For more information go to the following site: <http://www.rfc-editor.org>.

Table G.1 *RFCs for each protocol*

<i>Protocol</i>	<i>RFC</i>
ARP and RARP	826, 903, 925, 1027, 1293, 1329, 1433, 1868, 1931, 2390
BGP	1092, 1105, 1163, 1265, 1266, 1267, 1364, 1392, 1403, 1565, 1654, 1655, 1665, 1771, 1772, 1745, 1774, 2283
BOOTP and DHCP	951, 1048, 1084, 1395, 1497, 1531, 1532, 1533, 1534, 1541, 1542, 2131, 2132
CIDR	1322, 1478, 1479, 1517, 1817
DHCP	See BOOTP and DHCP
DNS	799, 811, 819, 830, 881, 882, 883, 897, 920, 921, 1034, 1035, 1386, 1480, 1535, 1536, 1537, 1591, 1637, 1664, 1706, 1712, 1713, 1982, 2065, 2137, 2317, 2535, 2671
FTP	114, 133, 141, 163, 171, 172, 238, 242, 250, 256, 264, 269, 281, 291, 354, 385, 412, 414, 418, 430, 438, 448, 463, 468, 478, 486, 505, 506, 542, 553, 624, 630, 640, 691, 765, 913, 959, 1635, 1785, 2228, 2577
HTML	1866
HTTP	2068, 2109
ICMP	777, 792, 1016, 1018, 1256, 1788, 2521
IGMP	966, 988, 1054, 1112, 1301, 1458, 1469, 1768, 2236, 2357, 2365, 2502, 2588
IMAP	See SMTP, MIME, POP, IMAP
IP	760, 781, 791, 815, 1025, 1063, 1071, 1141, 1190, 1191, 1624, 2113

Table G.1 *RFCs for each protocol (continued)*

<i>Protocol</i>	<i>RFC</i>
IPv6	1365, 1550, 1678, 1680, 1682, 1683, 1686, 1688, 1726, 1752, 1826, 1883, 1884, 1886, 1887, 1955, 2080, 2373, 2452, 2463, 2465, 2466, 2472, 2492, 2545, 2590
MIB	See SNMP, MIB, SMI
MIME	See SMTP, MIME, POP, IMAP
Multicast Routing	1584, 1585, 2117, 2362
NAT	1361, 2663, 2694
OSPF	1131, 1245, 1246, 1247, 1370, 1583, 1584, 1585, 1586, 1587, 2178, 2328, 2329, 2370
POP	See SMTP, MIME, POP, IMAP
RARP	See ARP and RARP
RIP	1131, 1245, 1246, 1247, 1370, 1583, 1584, 1585, 1586, 1587, 1722, 1723, 2082, 2453
SCTP	2960, 3257, 3284, 3285, 3286, 3309, 3436, 3554, 3708, 3758
SMI	See SNMP, MIB, SMI
SMTP, MIME, POP, IMAP	196, 221, 224, 278, 524, 539, 753, 772, 780, 806, 821, 934, 974, 1047, 1081, 1082, 1225, 1460, 1496, 1426, 1427, 1652, 1653, 1711, 1725, 1734, 1740, 1741, 1767, 1869, 1870, 2045, 2046, 2047, 2048, 2177, 2180, 2192, 2193, 2221, 2342, 2359, 2449, 2683, 2503
SNMP, MIB, SMI	1065, 1067, 1098, 1155, 1157, 1212, 1213, 1229, 1231, 1243, 1284, 1351, 1352, 1354, 1389, 1398, 1414, 1441, 1442, 1443, 1444, 1445, 1446, 1447, 1448, 1449, 1450, 1451, 1452, 1461, 1472, 1474, 1537, 1623, 1643, 1650, 1657, 1665, 1666, 1696, 1697, 1724, 1742, 1743, 1748, 1749
TCP	675, 700, 721, 761, 793, 879, 896, 1078, 1106, 1110, 1144, 1145, 1146, 1263, 1323, 1337, 1379, 1644, 1693, 1901, 1905, 2001, 2018, 2488, 2580
TELNET	137, 340, 393, 426, 435, 452, 466, 495, 513, 529, 562, 595, 596, 599, 669, 679, 701, 702, 703, 728, 764, 782, 818, 854, 855, 1184, 1205, 2355
TFTP	1350, 1782, 1783, 1784
UDP	768
VPN	2547, 2637, 2685
WWW	1614, 1630, 1737, 1738

APPENDIX H

UDP and TCP Ports

Table H.1 lists the common well-known ports ordered by port number.

Table H.1 *Ports by port number*

<i>Port Number</i>	<i>UDP/TCP</i>	<i>Protocol</i>
7	TCP	ECHO
13	UDP/TCP	DAYTIME
19	UDP/TCP	CHARACTER GENERATOR
20	TCP	FTP-DATA
21	TCP	FTP-CONTROL
23	TCP	TELNET
25	TCP	SMTP
37	UDP/TCP	TIME
67	UDP	BOOTP-SERVER
68	UDP	BOOTP-CLIENT
69	UDP	TFTP
70	TCP	GOPHER
79	TCP	FINGER
80	TCP	HTTP
109	TCP	POP-2
110	TCP	POP-3
111	UDP/TCP	RPC
161	UDP	SNMP
162	UDP	SNMP-TRAP
179	TCP	BGP
520	UDP	RIP

1066 APPENDIX H UDP AND TCP PORTS

Table H.2 lists the ports, ordered alphabetically by protocol.

Table H.2 Port numbers by protocol

<i>Protocol</i>	<i>UDP/TCP</i>	<i>Port Number</i>
BGP	TCP	179
BOOTP-SERVER	UDP	67
BOOTP-CLIENT	UDP	68
CHARACTER GENERATOR	UDP/TCP	19
DAYTIME	UDP/TCP	13
ECHO	TCP	7
FINGER	TCP	79
FTP-CONTROL	TCP	21
FTP-DATA	TCP	20
GOPHER	TCP	70
HTTP	TCP	80
POP-2	TCP	109
POP-3	TCP	110
RIP	UDP	520
RPC	UDP/TCP	111
SMTP	TCP	25
SNMP	UDP	161
SNMP-TRAP	UDP	162
TELNET	TCP	23
TFTP	UDP	69
TIME	UDP/TCP	37

Acronyms

AAL	application adaptation layer	BER	Basic Encoding Rules
ABM	asynchronous balanced mode	BGP	Border Gateway Protocol
ACK	acknowledgment	BNC	Bayone-Neill-Concelman
ACL	asynchronous connectionless link	BOOTP	Bootstrap Protocol
ADSL	asymmetric digital subscriber line	BSS	basic service set
AES	Advanced Encryption Standard	BUS	broadcast/unknown server
AH	Authentication Header	CA	Certification Authority
AM	amplitude modulation	CATV	community antenna TV
AMI	alternate mark inversion	CBC	cipher block chaining mode
AMPS	Advanced Mobile Phone System	CBR	constant bit rate
ANSI	American National Standards Institute	CBT	Core-Based Tree
AP	access point	CCITT	Consultative Committee for International Telegraphy and Telephony
ARP	Address Resolution Protocol	CCK	complementary code keying
ARPA	Advanced Research Projects Agency	CDMA	code division multiple access
ARPANET	Advanced Research Projects Agency Network	CFB	cipher feedback mode
ARQ	automatic repeat request	CGI	Common Gateway Interface
AS	authentication server	CHAP	Challenge Handshake Authentication Protocol
AS	autonomous system	CIDR	Classless InterDomain Routing
ASCII	American Standard Code for Information Interchange	CIR	committed information rate
ASK	amplitude shift keying	CLEC	competitive local exchange carrier
ASN.1	Abstract Syntax Notation 1	CMTS	cable modem transmission system
ATM	Asynchronous Transfer Mode	CRC	cyclic redundancy check
AUI	attachment unit interface	CS	convergence sublayer
B8ZS	bipolar with 8-zero substitution	CSM	cipher stream mode
Bc	committed burst size	CSMA	carrier sense multiple access
Be	excess burst size	CSMA/CA	carrier sense multiple access with collision avoidance
BECN	backward explicit congestion notification		

1068 ACRONYMS

CSMA/CD	carrier sense multiple access with collision detection	FSK	frequency shift keying
D-AMPS	digital AMPS	FTP	File Transfer Protocol
DARPA	Defense Advanced Research Projects Agency	GPS	Global Positioning System
dB	decibel	GSM	Global System for Mobile Communication
DC	direct current	HDLC	High-level Data Link Control
DCF	distributed coordination function	HDSL	high bit rate digital subscriber line
DCT	discrete cosine transform	HFC	hybrid-fiber-coaxial network
DDNS	Dynamic Domain Name System	HMAC	hashed-message authentication code
DDS	digital data service	HR-DSSS	High Rate Direct Sequence Spread Spectrum
DE	discard eligibility	HTML	HyperText Markup Language
DEMUX	demultiplexer	HTTP	HyperText Transfer Protocol
DES	data encryption standard	Hz	hertz
DHCP	Dynamic Host Configuration Protocol	IAB	Internet Architecture Board
DIFS	distributed interframe space	IANA	Internet Assigned Numbers Authority
DLCI	data link connection identifier	ICANN	Internet Corporation for Assigned Names and Numbers
DMT	discrete multitone technique	ICMP	Internet Control Message Protocol
DNS	Domain Name System	ICMPv6	Internet Control Message Protocol, version 6
DOCSIS	Data Over Cable System Interface Specifications	IEEE	Institute of Electrical and Electronics Engineers
DS	digital signal	IESG	Internet Engineering Steering Group
DS	Differentiated Services	IETF	Internet Engineering Task Force
DSL	digital subscriber line	IFS	interframe space
DSLAM	digital subscriber line access multiplexer	IGMP	Internet Group Management Protocol
DSSS	direct sequence spread spectrum	IKE	Internet Key Exchange
DVMRP	Distance Vector Multicast Routing Protocol	ILEC	incumbent local exchange carrier
DWDM	dense wave-division multiplexing	IMAP4	Internet Mail Access Protocol, version 4
EIA	Electronics Industries Association	INTERNIC	Internet Network Information Center
ESP	Encapsulating Security Payload	IntServ	Integrated Services
ESS	Extended Service Set	IP	Internet Protocol
FCC	Federal Communications Commission	IPCP	Internetwork Protocol Control Protocol
FDM	frequency-division multiplexing	IPng	Internet Protocol next generation
FDMA	frequency division multiple access	IPSec	IP Security
FDMA	frequency-division multiple access	IPv4	Internet Protocol version 4
FECN	forward explicit congestion notification	IPv6	Internet Protocol, version 6
FHSS	frequency hopping spread spectrum	IRTF	Internet Research Task Force
FIFO	first-in, first-out	IS-95	Interim Standard 95
FM	frequency modulation	ISAKMP	Internet Security Association and Key Management Protocol
FQDN	fully qualified domain name	ISO	International Organization of Standardization
FRAD	Frame Relay assembler/disassembler		

ISOC	Internet Society	MTU	maximum transfer unit
ISP	Internet service provider	MUX	multiplexer
ISUP	ISDN user port	NAP	network access point
ITM-2000	Internet Mobile Communication	NAT	network address translation
ITU-T	International Telecommunications Union–Telecommunication Standardization Sector	NAV	network allocation vector
IXC	interexchange carrier	NCP	Network Control Protocol
JPEG	Joint Photographic Experts Group	NIC	network interface card
KDC	key distribution center	NNI	network-to-network interface
L2CAP	Logical Link Control and Adaptation Protocol	NRM	normal response mode
LAN	local area network	NRZ	nonreturn to zero
LANE	LAN emulation	NRZ-I	nonreturn to zero, invert
LANE	local area network emulation	NRZ-L	nonreturn to zero, level
LATA	local access and transport area	NVT	Network Virtual Terminal
LCP	Link Control Protocol	OC	optical carrier
LEC	LAN emulation client	OFB	output feedback
LEC	local exchange carrier	OFDM	orthogonal frequency division multiplexing
LEO	low earth orbit	OSI	Open Systems Interconnection
LES	LAN emulation server	OSPF	open shortest path first
LLC	logical link control	PAM	pulse amplitude modulation
LMI	local management information	PAP	Password Authentication Protocol
LSA	link state advertisement	PCF	point coordination function
LSP	link state packet	PCM	pulse code modulation
MA	multiple access	PCS	personal communication system
MAA	message access agent	PGP	Pretty Good Privacy
MAC	medium access control sublayer	PHB	per hop behavior
MAC	message authentication code	PIM	Protocol Independent Multicast
MAN	metropolitan area network	PIM-DM	Protocol Independent Multicast, Dense Mode
MBONE	multicast backbone	PIM-SM	Protocol Independent Multicast, Sparse Mode
MDC	modification detection mode	PKI	public key infrastructure
MEO	medium Earth orbit	PM	phase modulation
MIB	Management Information Base	PN	pseudorandom noise
MII	medium independent interface	POP	point of presence
MIME	Multipurpose Internet Mail Extension	POP3	Post Office Protocol, version 3
MLT-3	multiline transmission, 3-level	POTS	plain old telephone system
MOSPF	Multicast Open Shortest Path First	PPP	Point-to-Point Protocol
MPEG	motion picture experts group	PQDN	partially qualified domain name
MSC	mobile switching center	PSK	phase shift keying
MTA	mail transfer agent	PVC	permanent virtual circuit
MTA	message transfer agent	QAM	quadrature amplitude modulation
MTSO	mobile telephone switching office	QoS	quality of service

1070 ACRONYMS

RADSL	rate adaptive asymmetrical digital subscriber line	STM	synchronous transport module
RARP	Reverse Address Resolution Protocol	STP	shielded twisted-pair
RFC	Request for Comment	STS	signal transport port
RIP	Routing Information Protocol	SVC	synchronous transport signal
ROM	read-only memory	TCAP	switched virtual circuit
RPB	reverse path broadcasting	TCP	transaction capabilities application port
RPF	reverse path forwarding	TCP/IP	Transmission Control Protocol
RPM	reverse path multicasting		Transmission Control Protocol/ Internetworking Protocol
RSA	Rivest, Shamir, Adleman	TDD-TDMA	time division duplexing TDMA
RSVP	Resource Reservation Protocol	TDM	time-division multiplexing
RTCP	Real-time Transport Control Protocol	TDMA	time division multiple access
RTP	Real-time Transport Protocol	TELNET	Terminal Network
RTSP	Real-Time Streaming Protocol	TFTP	Trivial File Transfer Protocol
RTT	round-trip time	TGS	ticket-granting server
RZ	return to zero	TLS	Transport Layer Security
SA	Security Association	TOS	type of service
SADB	security association database	TSI	time-slot interchange
SAR	segmentation and reassembly	TTL	time to live
SCCP	signaling connection control point	TUP	telephone user port
SCO	synchronous connection oriented	UA	user agent
SCP	server control point	UBR	unspecified bit rate
SCTP	Stream Control Transmission Protocol	UDP	User Datagram Protocol
SDH	Synchronous Digital Hierarchy	UNI	user network interface
SDSL	symmetric digital subscriber line	UNI	user-to-network interface
SEAL	simple and efficient adaptation layer	URL	Uniform Resource Locator
SHA-1	Secure Hash Algorithm 1	UTP	unshielded twisted-pair
SIFS	short interframe space	VBR	variable bit rate
SIP	Session Initiation Protocol	VC	virtual circuit
SMI	Structure of Management Information	VDSL	very high bit rate digital subscriber line
SMTP	Simple Mail Transfer Protocol	VLAN	virtual local area network
SNMP	Simple Network Management Protocol	VOFR	Voice Over Frame Relay
SNR	signal-to-noise ratio	VPN	virtual private network
SONET	Synchronous Optical Network	VT	virtual tributary
SP	signal point	WAN	wide area network
SPE	synchronous payload envelope	WATS	wide area telephone service
SPI	security parameter index	WDM	wave-division multiplexing
SS7	Signaling System Seven	WWW	World Wide Web
SSL	Secure Socket Layer		

Glossary

- 1000Base-CX** The two-wire STP implementation of Gigabit Ethernet.
- 1000Base-LX** The two-wire fiber implementation of Gigabit Ethernet using long-wave laser.
- 1000Base-SX** The two-wire fiber implementation of Gigabit Ethernet using short-wave laser.
- 1000Base-T** The four-wire UTP implementation of Gigabit Ethernet.
- 100Base-FX** The two-wire fiber implementation of Fast Ethernet.
- 100Base-T4** The four-wire UTP implementation of Fast Ethernet.
- 100Base-TX** The two-wire UTP implementation of Fast Ethernet.
- 10Base2** The thin coaxial cable implementation of Standard Ethernet.
- 10Base5** The thick coaxial cable implementation of Standard Ethernet.
- 10Base-F** The fiber implementation of Standard Ethernet.
- 10Base-T** The twisted-pair implementation of Standard Ethernet.
- 10GBase-E** The extended implementation of Ten-Gigabit Ethernet.
- 10GBase-L** The fiber implementation of Ten-Gigabit Ethernet using long-wave laser.
- 10GBase-S** The fiber implementation of Ten-Gigabit Ethernet using short-wave laser.
- 1-persistent strategy** A CSMA persistence strategy in which a station sends a frame immediately if the line is idle.
- 2B1Q encoding** A line encoding technique in which each pulse represents 2 bits.
- 4B/5B encoding** A block coding technique in which 4 bits are encoded into a 5-bit code.
- 8B/10B encoding** A block coding technique in which 8 bits are encoded into a 10-bit code.
- 8B6T encoding** A three-level line encoding scheme that encodes a block of 8 bits into a signal of 6 ternary pulses.
- 4-dimensional, 5-level pulse amplitude modulation (4D-PAM5)** An encoding scheme used by 1000Base-T.
- 56K modem** A modem technology using two different data rates: one for uploading and one for downloading from the Internet.

A

Abstract Syntax Notation 1 (ASN.1) A standard for representing simple and structured data.

access point (AP) A central base station in a BSS.

acknowledgment (ACK) A response sent by the receiver to indicate the successful receipt of data.

active document In the World Wide Web, a document executed at the local site using Java.

adaptive delta modulation A delta modulation technique in which the value of delta changes according to the amplitude of the analog signal.

add/drop multiplexer A SONET device that removes and inserts signals in a path without demultiplexing and re-multiplexing.

additive increase With slow start, a congestion avoidance strategy in which the window size is increased by just one segment instead of exponentially.

address aggregation A mechanism in which the blocks of addresses for several organizations are aggregated into one larger block.

Address Resolution Protocol (ARP) In TCP/IP, a protocol for obtaining the physical address of a node when the Internet address is known.

address space The total number of addresses available by a protocol.

ADSL Lite A splitterless ADSL. This technology allows an ASDL Lite modem to be plugged directly into a telephone jack and connected to the computer. The splitting is done at the telephone company.

Advanced Encryption Standard (AES) A secret-key cryptosystem adapted by NIST to replace DES.

Advanced Mobile Phone System (AMPS) A North American analog cellular phone system using FDMA.

Advanced Research Projects Agency (ARPA) The government agency that funded ARPANET.

Advanced Research Projects Agency Network (ARPANET) The packet-switching network that was funded by ARPA.

ALOHA The original random multiple access method in which a station can send a frame any time it has one to send.

alternate mark inversion (AMI) A digital-to-digital bipolar encoding method in which the amplitude representing 1 alternates between positive and negative voltages.

American National Standards Institute (ANSI) A national standards organization that defines standards in the United States.

American Standard Code for Information Interchange (ASCII) A character code developed by ANSI that used extensively for data communication.

amplitude The strength of a signal, usually measured in volts.

amplitude modulation (AM) An analog-to-analog conversion method in which the carrier signal's amplitude varies with the amplitude of the modulating signal.

amplitude shift keying (ASK) A modulation method in which the amplitude of the carrier signal is varied to represent binary 0 or 1.

analog data Data that are continuous and smooth and not limited to a specific number of values.

analog signal A continuous waveform that changes smoothly over time.

analog-to-analog conversion The representation of analog information by an analog signal.

analog-to-digital conversion The representation of analog information by a digital signal.

angle of incidence In optics, the angle formed by a light ray approaching the interface between two media and the line perpendicular to the interface.

anycast address An address that defines a group of computers with addresses that have the same beginning.

aperiodic signal A signal that does not exhibit a pattern or repeating cycle.

applet A computer program for creating an active Web document. It is usually written in Java.

application adaptation layer (AAL) A layer in ATM protocol that breaks user data into 48-byte payloads.

application layer The fifth layer in the Internet model; provides access to network resources.

area A collection of networks, hosts, and routers all contained within an autonomous system.

association A connection in SCTP.

asymmetric digital subscriber line (ADSL) A communication technology in which the downstream data rate is higher than the upstream rate.

asynchronous balanced mode (ABM) In HDLC, a communication mode in which all stations are equal.

asynchronous connectionless link (ACL) A link between a Bluetooth master and slave in which a corrupted payload is retransmitted.

Asynchronous Transfer Mode (ATM) A wide area protocol featuring high data rates and equal-sized packets (cells); ATM is suitable for transferring text, audio, and video data.

asynchronous transmission Transfer of data with start and stop bit(s) and a variable time interval between data units.

ATM LAN A LAN using ATM technology.

ATM layer A layer in ATM that provides routing, traffic management, switching, and multiplexing services.

attachment unit interface (AUI) A 10Base5 cable that performs the physical interface functions between the station and the transceiver.

attenuation The loss of a signal's energy due to the resistance of the medium.

audio Recording or transmitting of sound or music.

authentication Verification of the sender of a message.

Authentication Header (AH) Protocol A protocol defined by IPSec at the network layer that provides integrity to a message through the creation of a digital signature by a hashing function.

authentication server (AS) The KDC in the Kerberos protocol.

automatic repeat request (ARQ) An error-control method in which correction is made by retransmission of data.

autonegotiation A Fast Ethernet feature that allows two devices to negotiate the mode or data rate.

autonomous system (AS) A group of networks and routers under the authority of a single administration.

B

backward explicit congestion notification (BECN) A bit in the Frame Relay packet that notifies the sender of congestion.

band-pass channel A channel that can pass a range of frequencies.

bandwidth The difference between the highest and the lowest frequencies of a composite signal. It also measures the information-carrying capacity of a line or a network.

bandwidth on demand A digital service that allows subscribers higher speeds through the use of multiple lines.

bandwidth-delay product A measure of the number of bits that can be sent while waiting for news from the receiver.

banyan switch A multistage switch with microswitches at each stage that route the packets based on the output port represented as a binary string.

Barker sequence A sequence of 11 bits used for spreading.

baseband transmission Transmission of digital or analog signal without modulation using a low-pass channel.

base header In IPv6, the main header of the datagram.

baseline wandering In decoding a digital signal, the receiver calculates a running average of the received signal power. This average is called the baseline. A long string of 0s or 1s can cause a drift in the baseline (baseline wandering) and make it difficult for the receiver to decode correctly.

Basic Encoding Rule (BER) A standard that encodes data to be transferred through a network.

Basic Latin ASCII character set.

basic service set (BSS) The building block of a wireless LAN as defined by the IEEE 802.11 standard.

Batcher-banyan switch A banyan switch that sorts the arriving packets based on their destination port.

baud rate The number of signal elements transmitted per second. A signal element consists of one or more bits.

Bayone-Neill-Concelman (BNC) connector A common coaxial cable connector.

bidirectional authentication An authentication method involving a challenge and a response from sender to receiver and vice versa.

bidirectional frame (B-frame) An MPEG frame that is related to the preceding and following I-frame or P-frame.

binary exponential backup In contention access methods, a retransmission delay strategy used by a system to delay access.

binary notation Representation of IP addresses in binary.

biphase A type of polar encoding where the signal changes at the middle of the bit interval. Manchester and differential Manchester are examples of biphase encoding.

bipolar encoding A digital-to-digital encoding method in which 0 amplitude represents binary 0 and positive and negative amplitudes represent alternate 1s.

bipolar with 8-zero substitution (B8ZS) A scrambling technique in which a stream of 8 zeros are replaced by a predefined pattern to improve bit synchronization.

bit Binary digit. The smallest unit of data (0 or 1).

bit rate The number of bits transmitted per second.

bit stuffing In a bit-oriented protocol, the process of adding an extra bit in the data section of a frame to prevent a sequence of bits from looking like a flag.

bit-oriented protocol A protocol in which the data frame is interpreted as a sequence of bits.

block cipher An encryption/decryption algorithm that has a block of bits as its basic unit.

block code An error detection/correction code in which data are divided into units called datawords. Redundant bits are added to each dataword to create a codeword.

block coding A coding method to ensure synchronization and detection of errors.

blocking An event that occurs when a switched network is working at its full capacity and cannot accept more input.

Bluetooth A wireless LAN technology designed to connect devices of different functions such as telephones and notebooks in a small area such as a room.

Bootstrap Protocol (BOOTP) The protocol that provides configuration information from a table (file).

Border Gateway Protocol (BGP) An interautonomous system routing protocol based on path vector routing.

bridge A network device operating at the first two layers of the Internet model with filtering and forwarding capabilities.

broadband transmission Transmission of signals using modulation of a higher frequency signal. The term implies a wide-bandwidth data combined from different sources.

broadcast address An address that allows transmission of a message to all nodes of a network.

broadcast/unknown server (BUS) A server connected to an ATM switch that can multicast and broadcast frames.

broadcasting Transmission of a message to all nodes in a network.

browser An application program that displays a WWW document. A browser usually uses other Internet services to access the document.

BSS-transition mobility In a wireless LAN, a station that can move from one BSS to another but is confined inside one ESS.

bucket brigade attack See *man-in-the middle attack*.

burst error Error in a data unit in which two or more bits have been altered.

bursty data Data with varying instantaneous transmission rates.

bus topology A network topology in which all computers are attached to a shared medium.

byte stuffing In a byte-oriented protocol, the process of adding an extra byte in the data section of a frame to prevent a byte from looking like a flag.

byte-oriented protocol A protocol in which the data section of the frame is interpreted as a sequence of bytes (characters).

C

cable modem A technology in which the TV cable provides Internet access.

cable modem transmission system (CMTS) A device installed inside the distribution hub that receives data from the Internet and passes them to the combiner.

cable TV network A system using coaxial or fiber optic cable that brings multiple channels of video programs into homes.

caching The storing of information in a small, fast memory.

Caesar cipher A shift cipher used by Julius Caesar with the key value of 3.

carrier extension A technique in Gigabit Ethernet that increases the minimum length of the frame to achieve a higher maximum cable length.

carrier sense multiple access (CSMA) A contention access method in which each station listens to the line before transmitting data.

carrier sense multiple access with collision avoidance (CSMA/CA) An access method in which collision is avoided.

carrier sense multiple access with collision detection (CSMA/CD) An access method in which stations transmit whenever the transmission medium is available and retransmit when collision occurs.

carrier signal A high frequency signal used for digital-to-analog or analog-to-analog modulation. One of the characteristics of the carrier signal (amplitude, frequency, or phase) is changed according to the modulating data.

cell A small, fixed-size data unit; also, in cellular telephony, a geographical area served by a cell office.

cell network A network using the cell as its basic data unit.

cellular telephony A wireless communication technique in which an area is divided into cells. A cell is served by a transmitter.

Certification Authority (CA) An agency such as a federal or state organization that binds a public key to an entity and issues a certificate.

Challenge Handshake Authentication Protocol (CHAP) In PPP, a three-way handshaking protocol used for authentication.

channel A communications pathway.

channelization A multiple access method in which the available bandwidth of a link is shared in time.

character-oriented protocol See *byte-oriented protocol*.

checksum A value used for error detection. It is formed by adding data units using one's complement arithmetic and then complementing the result.

chip In CDMA, a number in a code that is assigned to a station.

choke point A packet sent by a router to the source to inform it of congestion.

chunk A unit of transmission in SCTP.

cipher An encryption/decryption algorithm.

cipher block chaining (CBC) mode A DES and triple DES operation mode in which the encryption (or decryption) of a block depends on all previous blocks.

cipher feedback mode (CFB) A DES and triple DES operation mode in which data is sent and received 1 bit at a time, with each bit independent of the previous bits.

cipher stream mode (CSM) A DES and triple DES operation mode in which data is sent and received 1 byte at a time.

cipher suite A list of possible ciphers.

ciphertext The encrypted data.

circuit switching A switching technology that establishes an electrical connection between stations using a dedicated path.

cladding Glass or plastic surrounding the core of an optical fiber; the optical density of the cladding must be less than that of the core.

classful addressing An IPv4 addressing mechanism in which the IP address space is divided into 5 classes: A, B, C, D, and E. Each class occupies some part of the whole address space.

classless addressing An addressing mechanism in which the IP address space is not divided into classes.

Classless InterDomain Routing (CIDR) A technique to reduce the number of routing table entries when supernetting is used.

client process A running application program on a local site that requests service from a running application program on a remote site.

client-server model The model of interaction between two application programs in which a program at one end (client) requests a service from a program at the other end (server).

closed-loop congestion control A method to alleviate congestion after it happens.

coaxial cable A transmission medium consisting of a conducting core, insulating material, and a second conducting sheath.

code division multiple access (CDMA) A multiple access method in which one channel carries all transmissions simultaneously.

codeword The encoded dataword.

ColdFusion A dynamic web technology that allows the fusion of data items coming from a conventional database.

collision The event that occurs when two transmitters send at the same time on a channel designed for only one transmission at a time; data will be destroyed.

collision domain The length of the medium subject to collision.

committed burst size (Bc) The maximum number of bits in a specific time period that a Frame Relay network must transfer without discarding any frames.

committed information rate (CIR) The committed burst size divided by time.

common carrier A transmission facility available to the public and subject to public utility regulation.

Common Gateway Interface (CGI) A standard for communication between HTTP servers and executable programs. CGI is used in creating dynamic documents.

community antenna TV (CATV) A cable network service that broadcasts video signals to locations with poor or no reception.

compatible address An IPv6 address consisting of 96 bits of zero followed by 32 bits of IPv4.

competitive local exchange carrier (CLEC) A telephone company that cannot provide main telephone services; instead, other services such as mobile telephone service and toll calls inside a LATA are provided.

complementary code keying (CCK) An HR-DSSS encoding method that encodes four or eight bits into one symbol.

composite signal A signal composed of more than one sine wave.

congestion Excessive network or internetwork traffic causing a general degradation of service.

connecting device A tool that connects computers or networks.

connection establishment The preliminary setup necessary for a logical connection prior to actual data transfer.

connectionless service A service for data transfer without connection establishment or termination.

constant bit rate (CBR) The data rate of an ATM service class that is designed for customers requiring real-time audio or video services.

constellation diagram A graphical representation of the phase and amplitude of different bit combinations in digital-to-analog modulation.

Consultative Committee for International Telegraphy and Telephony (CCITT) An international standards group now known as the ITU-T.

contention An access method in which two or more devices try to transmit at the same time on the same channel.

controlled access A multiple access method in which the stations consult one another to determine who has the right to send.

convergence sublayer (CS) In ATM protocol, the upper AAL sublayer that adds a header or a trailer to the user data.

cookie A string of characters that holds some information about the client and must be returned to the server untouched.

core The glass or plastic center of an optical fiber.

Core-Based Tree (CBT) In multicasting, a group-shared protocol that uses a center router as the root of the tree.

country domain A subdomain in the Domain Name System that uses two characters as the last suffix.

crossbar switch A switch consisting of a lattice of horizontal and vertical paths. At the intersection of each horizontal and vertical path, there is a crosspoint that can connect the input to the output.

crosspoint The junction of an input and an output on a crossbar switch.

crosstalk The noise on a line caused by signals traveling along another line.

cryptography The science and art of transforming messages to make them secure and immune to attacks.

cyclic code A linear code in which the cyclic shifting (rotation) of each codeword creates another code word.

cyclic redundancy check (CRC) A highly accurate error-detection method based on interpreting a pattern of bits as a polynomial.

D

data element The smallest entity that can represent a piece of information. A bit.

data encryption standard (DES) The U.S. government standard encryption method for nonmilitary and nonclassified use.

data link connection identifier (DLCI) A number that identifies the virtual circuit in Frame Relay.

- data link control** The responsibilities of the data link layer: flow control and error control.
- data link layer** The second layer in the Internet model. It is responsible for node-to-node delivery.
- Data Over Cable System Interface Specifications (DOCSIS)** A standard for data transmission over an HFC network.
- data rate** The number of data elements sent in one second.
- data transfer phase** The intermediate phase in circuit-switched or virtual-circuit network in which data transfer takes place.
- data transparency** The ability to send any bit pattern as data without it being mistaken for control bits.
- datagram** In packet switching, an independent data unit.
- datagram network** A packet-switched network in which packets are independent from each other.
- dataword** The smallest block of data in block coding.
- de facto standard** A protocol that has not been approved by an organized body but adopted as a standard through widespread use.
- de jure standard** A protocol that has been legislated by an officially recognized body.
- deadlock** A situation in which a task cannot proceed because it is waiting for an even that will never occur.
- decibel (dB)** A measure of the relative strength of two signal points.
- decryption** Recovery of the original message from the encrypted data.
- default mask** The mask for a network that is not subnetted.
- default routing** A routing method in which a router is assigned to receive all packets with no match in the routing table.
- Defense Advanced Research Projects Agency (DARPA)** A government organization, which, under the name of ARPA funded ARPANET and the Internet.
- delta modulation** An analog-to-digital conversion technique in which the value of the digital signal is based on the difference between the current and the previous sample values.
- demodulation** The process of separating the carrier signal from the information-bearing signal.
- demultiplexer (DEMUX)** A device that separates a multiplexed signal into its original components.
- denial of service attack** A form of attack in which the site is flooded with so many phony requests that is eventually forced to deny service.
- dense wave-division multiplexing (DWDM)** A WDM method that can multiplex a very large number of channels by spacing channels closer together.
- differential Manchester encoding** A digital-to-digital polar encoding method that features a transition at the middle of the bit interval as well as an inversion at the beginning of each 1 bit.
- Differentiated Services (DS or Diffserv)** A class-based QoS model designed for IP.
- Diffie-Hellman protocol** A key management protocol that provides a one-time session key for two parties.
- digest** A condensed version of a document.
- digital AMPS (D-AMPS)** A second-generation cellular phone system that is a digital version of AMPS.

- digital data** Data represented by discrete values or conditions.
- digital data service (DDS)** A digital version of an analog leased line with a rate of 64 Kbps.
- digital signal** A discrete signal with a limited number of values.
- digital signal (DS) service** A telephone company service featuring a hierarchy of digital signals.
- digital signature** A method to authenticate the sender of a message.
- digital subscriber line (DSL)** A technology using existing telecommunication networks to accomplish high-speed delivery of data, voice, video, and multimedia.
- digital subscriber line access multiplexer (DSLAM)** A telephone company site device that functions like an ADSL modem.
- digital-to-analog conversion** The representation of digital information by an analog signal.
- digital-to-digital conversion** The representation of digital information by a digital signal.
- digitization** Conversion of analog information to digital information.
- Dijkstra's algorithm** In link state routing, an algorithm that finds the shortest path to other routers.
- direct current (DC)** A zero-frequency signal with a constant amplitude.
- direct delivery** A delivery in which the final destination of the packet is a host connected to the same physical network as the sender.
- direct sequence spread spectrum (DSSS)** A wireless transmission method in which each bit to be sent by the sender is replaced by a sequence of bits called a chip code.
- discard eligibility (DE)** A bit that identifies a packet that can be discarded if there is congestion in the network.
- discrete cosine transform (DCT)** A JPEG phase in which a transformation changes the 64 values so that the relative relationships between pixels are kept but the redundancies are revealed.
- discrete multitone technique (DMT)** A modulation method combining elements of QAM and FDM.
- Distance Vector Multicast Routing Protocol (DVMRP)** A protocol based on distance vector routing that handles multicast routing in conjunction with IGMP.
- distance vector routing** A routing method in which each router sends its neighbors a list of networks it can reach and the distance to that network.
- distortion** Any change in a signal due to noise, attenuation, or other influences.
- distributed coordination function (DCF)** The basic access method in wireless LANs; stations contend with each other to get access to the channel.
- distributed database** Information stored in many locations.
- distributed interframe space (DIFS)** In wireless LANs, a period of time that a station waits before sending a control frame.
- distributed processing** A strategy in which services provided for the network reside at multiple sites.
- DNS server** A computer that holds information about the name space.
- domain name** In the DNS, a sequence of labels separated by dots.
- domain name space** A structure for organizing the name space in which the names are defined in an inverted-tree structure with the root at the top.

Domain Name System (DNS) A TCP/IP application service that converts user-friendly names to IP addresses.

dotted-decimal notation A notation devised to make the IP address easier to read; each byte is converted to its decimal equivalent and then set off from its neighbor by a decimal.

downlink Transmission from a satellite to an earth station.

downloading Retrieving a file or data from a remote site.

dynamic document A Web document created by running a CGI program at the server site.

Dynamic Domain Name System (DDNS) A method to update the DNS master file dynamically.

Dynamic Host Configuration Protocol (DHCP) An extension to BOOTP that dynamically assigns configuration information.

dynamic mapping A technique in which a protocol is used for address resolution.

dynamic routing Routing in which the routing table entries are updated automatically by the routing protocol.

E

E lines The European equivalent of T lines.

electromagnetic spectrum The frequency range occupied by electromagnetic energy.

electronic code block (ECB) mode A DES and triple DES operation method in which a long message is divided into 64-bit blocks before being encrypted separately.

Electronics Industries Association (EIA) An organization that promotes electronics manufacturing concerns. It has developed interface standards such as EIA-232, EIA-449, and EIA-530.

Encapsulating Security Payload (ESP) A protocol defined by IPSec that provides privacy as well as a combination of integrity and message authentication.

encapsulation The technique in which a data unit from one protocol is placed within the data field portion of the data unit of another protocol.

encryption Converting a message into an unintelligible form that is unreadable unless decrypted.

end office A switching office that is the terminus for the local loops.

end system A sender or receiver of data.

ephemeral port number A port number used by the client.

error control The handling of errors in data transmission.

Ethernet A local area network using the CSMA/CD access method.

excess burst size (Be) In Frame Relay, the maximum number of bits in excess of B_c that the user can send during a predefined period of time.

Extended Service Set (ESS) A wireless LAN service composed of two or more BSSs with APs as defined by the IEEE 802.11 standard.

exterior routing Routing between autonomous systems.

extranet A private network that uses the TCP/IP protocol suite that allows authorized access from outside users.

F

Fast Ethernet Ethernet with a data rate of 100 Mbps.

fast retransmission Retransmission of a segment in the TCP protocol when three acknowledgments have been received that imply the loss or corruption of that segment.

Federal Communications Commission (FCC) A government agency that regulates radio, television, and telecommunications.

fiber-optic cable A high-bandwidth transmission medium that carries data signals in the form of pulses of light. It consists of a thin cylinder of glass or plastic, called the core, surrounded by a concentric layer of glass or plastic called the cladding.

File Transfer Protocol (FTP) In TCP/IP, an application layer protocol that transfers files between two sites.

filtering A process in which a bridge makes forwarding decisions.

finite state machine A machine that goes through a limited number of states.

firewall A device (usually a router) installed between the internal network of an organization and the rest of the Internet to provide security.

first-in, first-out (FIFO) queue A queue in which the first item in is the first item out.

flag A bit pattern or a character added to the beginning and the end of a frame to separate the frames.

flat name space A name space in which there is no hierarchical structure.

flooding Saturation of a network with a message.

flow control A technique to control the rate of flow of frames (packets or messages).

footprint An area on Earth that is covered by a satellite at a specific time.

forward error correction Correction of errors at the receiver.

forward explicit congestion notification (FECN) A bit in the Frame Relay packet that notifies the destination of congestion.

forwarding Placing the packet in its route to its destination.

Fourier analysis The mathematical technique used to obtain the frequency spectrum of an aperiodic signal if the time-domain representation is given.

fragmentation The division of a packet into smaller units to accommodate a protocol's MTU.

frame A group of bits representing a block of data.

frame bursting A technique in CSMA/CD Gigabit Ethernet in which multiple frames are logically connected to each other to resemble a longer frame.

Frame Relay A packet-switching specification defined for the first two layers of the Internet model. There is no network layer. Error checking is done on end-to-end basis instead of on each link.

Frame Relay assembler/disassembler (FRAD) A device used in Frame Relay to handle frames coming from other protocols.

frequency The number of cycles per second of a periodic signal.

frequency division multiple access (FDMA) A multiple access method in which the bandwidth is divided into channels.

frequency hopping spread spectrum (FHSS) A wireless transmission method in which the sender transmits at one carrier frequency for a short period of time, then hops to another

carrier frequency for the same amount of time, hops again for the same amount of time, and so on. After N hops, the cycle is repeated.

frequency modulation (FM) An analog-to-analog modulation method in which the carrier signal's frequency varies with the amplitude of the modulating signal.

frequency shift keying (FSK) A digital-to-analog encoding method in which the frequency of the carrier signal is varied to represent binary 0 or 1.

frequency-division multiple access (FDMA) An access method technique in which multiple sources use assigned bandwidth in a data communication band.

frequency-division multiplexing (FDM) The combining of analog signals into a single signal.

frequency-domain plot A graphical representation of a signal's frequency components.

full-duplex mode A transmission mode in which both parties can communicate simultaneously.

full-duplex switched Ethernet Ethernet in which each station, in its own separate collision domain, can both send and receive.

fully qualified domain name (FQDN) A domain name consisting of labels beginning with the host and going back through each level to the root node.

fundamental frequency The frequency of the dominant sine wave of a composite signal.

G

gatekeeper In the H.323 standard, a server on the LAN that plays the role of the registrar server.

gateway A device used to connect two separate networks that use different communication protocols.

generic domain A subdomain in the domain name system that uses generic suffixes.

geographical routing A routing technique in which the entire address space is divided into blocks based on physical landmasses.

Gigabit Ethernet Ethernet with a 1000 Mbps data rate.

Global Positioning System (GPS) An MEO public satellite system consisting of 24 satellites and used for land and sea navigation. GPS is not used for communications.

Global System for Mobile Communication (GSM) A second-generation cellular phone system used in Europe.

Globalstar An LEO satellite system with 48 satellites in six polar orbits with each orbit hosting eight satellites.

Go-Back-N ARQ An error-control method in which the frame in error and all following frames must be retransmitted.

grafting Resumption of multicast messages.

ground propagation Propagation of radio waves through the lowest portion of the atmosphere (hugging the earth).

group-shared tree A multicast routing feature in which each group in the system shares the same tree.

guard band A bandwidth separating two signals.

guided media Transmission media with a physical boundary.

H

H.323 A standard designed by ITU to allow telephones on the public telephone network to talk to computers (called terminals in H.323) connected to the Internet.

half-duplex mode A transmission mode in which communication can be two-way but not at the same time.

Hamming code A method that adds redundant bits to a data unit to detect and correct bit errors.

Hamming distance The number of differences between the corresponding bits in two datawords.

handoff Changing to a new channel as a mobile device moves from one cell to another.

harmonics Components of a digital signal, each having a different amplitude, frequency, and phase.

hash function An algorithm that creates a fixed-size digest from a variable-length message.

hashed-message authentication code (HMAC) A MAC based on a keyless hash function such as SHA-1.

header Control information added to the beginning of a data packet.

hertz (Hz) Unit of measurement for frequency.

hexadecimal colon notation In IPv6, an address notation consisting of 32 hexadecimal digits, with every four digits separated by a colon.

hierarchical routing A routing technique in which the entire address space is divided into levels based on specific criteria.

high bit rate digital subscriber line (HDSL) A service similar to the T1-line that can operate at lengths up to 3.6 km.

High Rate Direct Sequence Spread Spectrum (HR-DSSS) A signal generation method similar to DSSS except for the encoding method (CCK).

High-level Data Link Control (HDLC) A bit-oriented data link protocol defined by the ISO.

hop count The number of nodes along a route. It is a measurement of distance in routing algorithms.

hop-to-hop delivery Transmission of frames from one node to the next.

horn antenna A scoop-shaped antenna used in terrestrial microwave communication.

host A station or node on a network.

hostid The part of an IP address that identifies a host.

host-specific routing A routing method in which the full IP address of a host is given in the routing table.

hub A central device in a star topology that provides a common connection among the nodes.

Huffman encoding A statistical compression method using variable-length codes to encode a set of symbols.

hybrid network A network with a private internet and access to the global Internet.

hybrid-fiber-coaxial (HFC) network The second generation of cable networks; uses fiber optic and coaxial cable.

hypertext Information containing text that is linked to other documents through pointers.

HyperText Markup Language (HTML) The computer language for specifying the contents and format of a web document. It allows additional text to include codes that define fonts, layouts, embedded graphics, and hypertext links.

HyperText Transfer Protocol (HTTP) An application service for retrieving a web document.

I

inband signaling Using the same channel for data and control transfer.

incumbent local exchange carrier (ILEC) A telephone company that provided services before 1996 and is the owner of the cabling system.

indirect delivery A delivery in which the source and destination of a packet are in different networks.

infrared wave A wave with a frequency between 300 GHz and 400 THz; usually used for short-range communications.

inner product A number produced by multiplying two sequences, element by element, and summing the products.

Institute of Electrical and Electronics Engineers (IEEE) A group consisting of professional engineers which has specialized societies whose committees prepare standards in members' areas of specialty.

Integrated Services (IntServ) A flow-based QoS model designed for IP.

interactive audio/video Real-time communication with sound and images.

interautonomous system routing protocol A protocol to handle transmissions between autonomous systems.

interdomain routing Routing among autonomous systems.

interexchange carrier (IXC) A long-distance company that, prior to the Act of 1996, provided communication services between two customers in different LATAs.

interface The boundary between two pieces of equipment. It also refers to mechanical, electrical, and functional characteristics of the connection.

interference Any undesired energy that interferes with the desired signals.

interframe space (IFS) In wireless LANs, a time interval between two frames to control access to the channel.

Interim Standard 95 (IS-95) One of the dominant second-generation cellular telephony standards in North America.

interior routing Routing inside an autonomous system.

interleaving In multiplexing, taking a specific amount of data from each device in a regular order.

International Organization of Standardization (ISO) A worldwide organization that defines and develops standards on a variety of topics.

International Telecommunications Union–Telecommunication Standardization Sector (ITU–T) A standards organization formerly known as the CCITT.

internet A collection of networks connected by internetworking devices such as routers or gateways.

Internet A global internet that uses the TCP/IP protocol suite.

Internet address A 32-bit or 128-bit network-layer address used to uniquely define a host on an internet using the TCP/IP protocol.

Internet Architecture Board (IAB) The technical adviser to the ISOC; oversees the continuing development of the TCP/IP protocol suite.

Internet Assigned Numbers Authority (IANA) A group supported by the U.S. government that was responsible for the management of Internet domain names and addresses until October 1998.

Internet Control Message Protocol (ICMP) A protocol in the TCP/IP protocol suite that handles error and control messages.

Internet Control Message Protocol, version 6 (ICMPv6) A protocol in IPv6 that handles error and control messages.

Internet Corporation for Assigned Names and Numbers (ICANN) A private, nonprofit corporation managed by an international board that assumed IANA operations.

Internet draft A working Internet document (a work in progress) with no official status and a six-month lifetime.

Internet Engineering Steering Group (IESG) An organization that oversees the activities of IETF.

Internet Engineering Task Force (IETF) A group working on the design and development of the TCP/IP protocol suite and the Internet.

Internet Group Management Protocol (IGMP) A protocol in the TCP/IP protocol suite that handles multicasting.

Internet Key Exchange (IKE) A protocol designed to create security associations in SADBs.

Internet Mail Access Protocol, version 4 (IMAP4) A complex and powerful protocol to handle the transmission of electronic mail.

Internet Mobile Communication (ITM-2000) An ITU issued blueprint that defines criteria for third generation cellular telephony.

Internet model A 5-layer protocol stack that dominates data communications and networking today.

Internet Network Information Center (INTERNIC) An agency responsible for collecting and distributing information about TCP/IP protocols.

Internet Protocol (IP) The network-layer protocol in the TCP/IP protocol suite governing connectionless transmission across packet switching networks.

Internet Protocol next generation (IPng) See *Internet Protocol version 6 (IPv6)*.

Internet Protocol version 4 (IPv4) The current version of Internet Protocol.

Internet Protocol, version 6 (IPv6) The sixth version of the Internet Protocol.

Internet Research Task Force (IRTF) A forum of working groups focusing on long-term research topics related to the Internet.

Internet Security Association and Key Management Protocol (ISAKMP) A protocol designed by the National Security Agency (NSA) that actually implements the exchanges defined in IKE.

Internet service provider (ISP) Usually, a company that provides Internet services.

Internet Society (ISOC) The nonprofit organization established to publicize the Internet.

Internet standard A thoroughly tested specification that is useful to and adhered to by those who work with the Internet. It is a formalized regulation that must be followed.

internetwork (internet) A network of networks.

Internetwork Protocol Control Protocol (IPCP) In PPP, the set of protocols that establish and terminate a network layer connection for IP packets.

internetworking Connecting several networks together using internetworking devices such as routers and gateways.

intranet A private network that uses the TCP/IP protocol suite.

inverse domain A subdomain in the DNS that finds the domain name given the IP address.

inverse multiplexing Taking data from one source and breaking it into portions that can be sent across lower-speed lines.

IP datagram The Internetworking Protocol data unit.

IP Security (IPSec) A collection of protocols designed by the IETF (Internet Engineering Task Force) to provide security for a packet carried on the Internet.

IrDA port A port that allows a wireless keyboard to communicate with a PC.

Iridium A 66-satellite network that provides communication from any Earth site to another.

ISDN user port (ISUP) A protocol at the upper layer of SS7 that provides services similar to those of an ISDN network.

isochronous transmission A type of transmission in which the entire stream of bits is synchronized under the control of a common clock.

iterative resolution Resolution of the IP address in which the client may send its request to multiple servers before getting an answer.

J

jamming signal In CSMA/CD, a signal sent by the first station that detects collision to alert every other station of the situation.

Java A programming language used to create active Web documents.

jitter A phenomenon in real-time traffic caused by gaps between consecutive packets at the receiver.

Joint Photographic Experts Group (JPEG) A standard for compressing continuous-tone picture.

K

Kerberos An authentication protocol used by Windows 2000.

key distribution center (KDC) In secret key encryption, a trusted third party that shares a key with each user.

L

LAN emulation (LANE) Local area network emulation using ATM switches.

LAN emulation client (LEC) In ATM LANs, client software that receives services from a LES.

LAN emulation server (LES) In ATM LANs, server software that creates a virtual circuit between the source and destination.

leaky bucket algorithm An algorithm to shape bursty traffic.

least-cost tree An MOSPF feature in which the tree is based on a chosen metric instead of shortest path.

legacy ATM LAN LAN in which ATM technology is used as a backbone to connect traditional LANs.

line coding Converting binary data into signals.

linear block code A block code in which adding two codewords creates another codeword.

line-of-sight propagation The transmission of very high frequency signals in straight lines directly from antenna to antenna.

link The physical communication pathway that transfers data from one device to another.

Link Control Protocol (LCP) A PPP protocol responsible for establishing, maintaining, configuring, and terminating links.

link local address An IPv6 address used by a private LAN.

link state advertisement (LSA) In OSPF, a method to disperse information.

link state database In link state routing, a database common to all routers and made from LSP information.

link state packet (LSP) In link state routing, a small packet containing routing information sent by a router to all other routers.

link state routing A routing method in which each router shares its knowledge of changes in its neighborhood with all other routers.

local access and transport area (LATA) An area covered by one or more telephone companies.

local area network (LAN) A network connecting devices inside a single building or inside buildings close to each other.

local area network emulation (LANE) Software that enables an ATM switch to behave like a LAN switch.

local exchange carrier (LEC) A telephone company that handles services inside a LATA.

local loop The link that connects a subscriber to the telephone central office.

local management information (LMI) A protocol used in Frame Relay that provides management features.

logical address An address defined in the network layer.

logical link control (LLC) The upper sublayer of the data link layer as defined by IEEE Project 802.2.

Logical Link Control and Adaptation Protocol (L2CAP) A Bluetooth layer used for data exchange on an ACL link.

logical tunnel The encapsulation of a multicast packet inside a unicast packet to enable multicast routing by non-multicast routers.

longest mask matching The technique in CIDR in which the longest prefix is handled first when searching a routing table.

low earth orbit (LEO) A polar satellite orbit with an altitude between 500 and 2000 km. A satellite with this orbit has a rotation period of 90 to 120 minutes.

low-pass channel A channel that passes frequencies between 0 and f .

M

mail transfer agent (MTA) An SMTP component that transfers the mail across the Internet.

Management Information Base (MIB) The database used by SNMP that holds the information necessary for management of a network.

Manchester encoding A digital-to-digital polar encoding method in which a transition occurs at the middle of each bit interval to provide synchronization.

man-in-the-middle attack A key management problem in which an intruder intercepts and sends messages between the intended sender and receiver.

mapped address An IPv6 address used when a computer that has migrated to IPv6 wants to send a packet to a computer still using IPv4.

mask For IPv4, a 32-bit binary number that gives the first address in the block (the network address) when ANDed with an address in the block.

maximum transfer unit (MTU) The largest size data unit a specific network can handle.

medium access control (MAC) sublayer The lower sublayer in the data link layer defined by the IEEE 802 project. It defines the access method and access control in different local area network protocols.

medium Earth orbit (MEO) A satellite orbit positioned between the two Van Allen belts. A satellite at this orbit takes six hours to circle the earth.

mesh topology A network configuration in which each device has a dedicated point-to-point link to every other device.

message access agent (MAA) A client-server program that pulls the stored email messages.

message authentication A security measure in which the sender of the message is verified for every message sent.

message authentication code (MAC) A keyed hash function.

message transfer agent (MTA) An SMTP component that transfers the message across the Internet.

metric A cost assigned for passing through a network.

metropolitan area network (MAN) A network that can span a geographical area the size of a city.

microwave Electromagnetic waves ranging from 2 GHz to 40 GHz.

minimum Hamming distance In a set of words, the smallest Hamming distance between all possible pairs.

mobile host A host that can move from one network to another.

mobile switching center (MSC) In cellular telephony, a switching office that coordinates communication between all base stations and the telephone central office.

mobile telephone switching office (MTSO) An office that controls and coordinates communication between all of the cell offices and the telephone control office.

modem A device consisting of a modulator and a demodulator. It converts a digital signal into an analog signal (modulation) and vice versa (demodulation).

modification detection code (MDC) The digest created by a hash function.

modular arithmetic Arithmetic that uses a limited range of integers (0 to $n - 1$).

modulation Modification of one or more characteristics of a carrier wave by an information-bearing signal.

modulus The upper limit in modular arithmetic (n).

monoalphabetic substitution An encryption method in which each occurrence of a character is replaced by another character in the set.

motion picture experts group (MPEG) A method to compress videos.

multicast address An address used for multicasting.

multicast backbone (MBONE) A set of internet routers supporting multicasting through the use of tunneling.

Multicast Open Shortest Path First (MOSPF) A multicast protocol that uses multicast link state routing to create a source-based least cost tree.

multicast router A router with a list of loyal members related to each router interface that distributes the multicast packets.

multicast routing Moving a multicast packet to its destinations.

multicasting A transmission method that allows copies of a single packet to be sent to a selected group of receivers.

multihoming service A service provided by SCTP that allows a computer to be connected to different networks.

multiline transmission, 3-level (MLT-3) encoding A line coding scheme featuring 3 levels of signals and transitions at the beginning of the 1 bit.

multimode graded-index fiber An optical fiber with a core having a graded index of refraction.

multimode step-index fiber An optical fiber with a core having a uniform index of refraction. The index of refraction changes suddenly at the core/cladding boundary.

multiple access (MA) A line access method in which every station can access the line freely.

multiple unicasting Sending multiple copies of a message, each with a different unicast address.

multiplexer (MUX) A device used for multiplexing.

multiplexing The process of combining signals from multiple sources for transmission across a single data link.

multiplicative decrease A congestion avoidance technique in which the threshold is set to half of the last congestion window size, and the congestion window size starts from one again.

Multipurpose Internet Mail Extension (MIME) A supplement to SMTP that allows non-ASCII data to be sent through SMTP.

multistage switch An array of switches designed to reduce the number of crosspoints.

multistream service A service provided by SCTP that allows data transfer to be carried using different streams.

N

name space All the names assigned to machines on an internet.

name-address resolution Mapping a name to an address or an address to a name.

Needham-Schroeder protocol A key management protocol using multiple challenge-response interactions between 2 entities.

netid The part of an IP address that identifies the network.

network A system consisting of connected nodes that share data, hardware, and software.

network access point (NAP) A complex switching station that connects backbone networks.

network address An address that identifies a network to the rest of the Internet; it is the first address in a block.

network address translation (NAT) A technology that allows a private network to use a set of private addresses for internal communication and a set of global Internet addresses for external communication.

network allocation vector (NAV) In CSMA/CA, the amount of time that must pass before a station can check for an idle line.

Network Control Protocol (NCP) In PPP, a set of control protocols that allows the encapsulation of data coming from network layer protocols.

network interface card (NIC) An electronic device, internal or external to a station, that contains circuitry to enable the station to be connected to the network.

network layer The third layer in the Internet model, responsible for the delivery of a packet to the final destination.

Network Virtual Terminal (NVT) A TCP/IP application protocol that allows remote login.

network-specific routing Routing in which all hosts on a network share one entry in the routing table.

network-to-network interface (NNI) In ATM, the interface between two networks.

next-hop routing A routing method in which only the address of the next hop is listed in the routing table instead of a complete list of the stops the packet must make.

node An addressable communication device (e.g., a computer or router) on a network.

node-to-node delivery Transfer of a data unit from one node to the next.

noise Random electrical signals that can be picked by the transmission medium and cause degradation or distortion of the data.

noiseless channel An error-free channel.

noisy channel A channel that can produce error in data transmission.

nonce A large random number that is used once to distinguish a fresh authentication request from a used one.

nonpersistent strategy A random multiple access method in which a station waits a random period of time after a collision is sensed.

nonrepudiation A security aspect in which a receiver must be able to prove that a received message came from a specific sender.

nonreturn to zero (NRZ) A digital-to-digital polar encoding method in which the signal level is always either positive or negative.

nonreturn to zero, invert (NRZ-I) An NRZ encoding method in which the signal level is inverted each time a 1 is encountered.

nonreturn to zero, level (NRZ-L) An NRZ encoding method in which the signal level is directly related to the bit value.

normal response mode (NRM) In HDLC, a communication mode in which the secondary station must have permission from the primary station before transmission can proceed.

Nyquist bit rate The data rate based on the Nyquist theorem.

Nyquist theorem A theorem that states that the number of samples needed to adequately represent an analog signal is equal to twice the highest frequency of the original signal.

O

Oakley A key creation protocol, developed by Hilarie Orman, which is one of the three components of IKE protocol.

omnidirectional antenna An antenna that sends out or receives signals in all directions.

one's complement A representation of binary numbers in which the complement of a number is found by complementing all bits.

open shortest path first (OSPF) An interior routing protocol based on link state routing.

Open Systems Interconnection (OSI) model A seven-layer model for data communication defined by ISO.

open-loop congestion control Policies applied to prevent congestion.

optical carrier (OC) The hierarchy of fiber-optic carriers defined in SONET.

optical fiber A thin thread of glass or other transparent material to carry light beams.

orbit The path a satellite travels around the earth.

Orthogonal Frequency Division Multiplexing (OFDM) A multiplexing method similar to FDM, with all the subbands used by one source at a given time.

orthogonal sequence A sequence with special properties between elements.

Otway-Rees protocol A key management protocol with less steps than the Needham-Schroeder method.

out-of-band signaling Using two separate channels for data and control.

output feedback (OFB) mode A mode similar to the CFB mode with one difference. Each bit in the ciphertext is independent of the previous bit or bits.

P

packet switching Data transmission using a packet-switched network.

packet-filter firewall A firewall that forwards or blocks packets based on the information in the network-layer and transport-layer headers.

packet-switched network A network in which data are transmitted in independent units called packets.

parabolic dish antenna An antenna shaped like a parabola used for terrestrial microwave communication.

parallel transmission Transmission in which bits in a group are sent simultaneously, each using a separate link.

parity check An error-detection method using a parity bit.

partially qualified domain name (PQDN) A domain name that does not include all the levels between the host and the root node.

Password Authentication Protocol (PAP) A simple two-step authentication protocol used in PPP.

path vector routing A routing method on which BGP is based; in this method, the ASes through which a packet must pass are explicitly listed.

P-box A hardware circuit used in encryption that connects input to output.

peer-to-peer process A process on a sending and a receiving machine that communicates at a given layer.

per hop behavior (PHB) In the Diffserv model, a 6-bit field that defines the packet-handling mechanism for the packet.

period The amount of time required to complete one full cycle.

periodic signal A signal that exhibits a repeating pattern.

permanent virtual circuit (PVC) A virtual circuit transmission method in which the same virtual circuit is used between source and destination on a continual basis.

persistent connection A connection which the server leaves open for additional requests after sending a response.

Personal Communication System (PCS) A generic term for a commercial cellular system that offers several kinds of communication services.

phase The relative position of a signal in time.

phase modulation (PM) An analog-to-analog modulation method in which the carrier signal's phase varies with the amplitude of the modulating signal.

phase shift keying (PSK) A digital-to-analog modulation method in which the phase of the carrier signal is varied to represent a specific bit pattern.

PHY sublayer The transceiver in Fast Ethernet.

physical address The address of a device at the data link layer (MAC address).

physical layer The first layer of the Internet model, responsible for the mechanical and electrical specifications of the medium.

piconet A Bluetooth network.

piggybacking The inclusion of acknowledgment on a data frame.

pipelining In Go-Back-n ARQ, sending several frames before news is received concerning previous frames.

pixel A picture element of an image.

plain old telephone system (POTS) The conventional telephone network used for voice communication.

plaintext In encryption/decryption, the original message.

playback buffer A buffer that stores the data until they are ready to be played.

point coordination function (PCF) In wireless LANs, an optional and complex access method implemented in an infrastructure network.

point of presence (POP) A switching office where carriers can interact with each other.

point-to-point connection A dedicated transmission link between two devices.

Point-to-Point Protocol (PPP) A protocol for data transfer across a serial line.

poison reverse A feature added to split horizon in which a table entry that has come through one interface is set to infinity in the update packet.

polar encoding A digital-to-analog encoding method that uses two levels (positive and negative) of amplitude.

policy routing A path vector routing feature in which the routing tables are based on rules set by the network administrator rather than a metric.

poll In the primary/secondary access method, a procedure in which the primary station asks a secondary station if it has any data to transmit.

poll/final (P/F) bit A bit in the control field of HDLC; if the primary is sending, it can be a poll bit; if the secondary is sending, it can be a final bit.

poll/select An access method protocol using poll and select procedures. See *poll*. See *select*.

polling An access method in which one device is designated as a primary station and the others as the secondary stations. The access is controlled by the primary station.

polyalphabetic substitution An encryption method in which each occurrence of a character can have a different substitute.

polynomial An algebraic term that can represent a CRC divisor.

port address In TCP/IP protocol an integer that identifies a process.

port number See *port address*.

Post Office Protocol, version 3 (POP3) A popular but simple SMTP mail access protocol.

p-persistent A CSMA persistence strategy in which a station sends with probability p if it finds the line idle.

preamble The 7-byte field of an IEEE 802.3 frame consisting of alternating 1s and 0s that alert and synchronize the receiver.

predictive encoding In audio compression, encoding only the differences between the samples.

prefix The common part of an address range.

presentation layer The sixth layer of the OSI model; responsible for translation, encryption, authentication, and data compression.

Pretty Good Privacy (PGP) A protocol that provides all four aspects of security in the sending of email.

primary station In primary/secondary access method, a station that issues commands to the secondary stations.

priority queueing A queuing technique in which packets are assigned to a priority class, each with its own queue.

privacy A security aspect in which the message makes sense only to the intended receiver.

private key In conventional encryption, a key shared by only one pair of devices, a sender and a receiver. In public-key encryption, the private key is known only to the receiver.

private network A network that is isolated from the Internet.

process A running application program.

process-to-process delivery Delivery of a packet from the sending process to the destination process.

Project 802 The project undertaken by the IEEE in an attempt to solve LAN incompatibility. See also *IEEE Project 802*.

propagation speed The rate at which a signal or bit travels; measured by distance/second.

propagation time The time required for a signal to travel from one point to another.

protocol Rules for communication.

Protocol Independent Multicast (PIM) A multicasting protocol family with two members, PIM-DM and PIM-SM; both protocols are unicast-protocol dependent.

Protocol Independent Multicast, Dense Mode (PIM-DM) A source-based routing protocol that uses RPF and pruning/grafting strategies to handle multicasting.

Protocol Independent Multicast, Sparse Mode (PIM-SM) A group-shared routing protocol that is similar to CBT and uses a rendezvous point as the source of the tree.

protocol suite A stack or family of protocols defined for a complex communication system.

proxy ARP A technique that creates a subnetting effect; one server answers ARP requests for multiple hosts.

proxy firewall A firewall that filters a message based on the information available in the message itself (at the application layer).

proxy server A computer that keeps copies of responses to recent requests.

pruning Stopping the sending of multicast messages from an interface.

pseudoheader Information from the IP header used only for checksum calculation in the UDP and TCP packet.

pseudorandom noise (PN) A pseudorandom code generator used in FHSS.

public key infrastructure (PKI) A hierarchical structure of CA servers.

public-key cryptography A method of encryption based on a nonreversible encryption algorithm. The method uses two types of keys: The public key is known to the public; the private key (secret key) is known only to the receiver.

pulse amplitude modulation (PAM) A technique in which an analog signal is sampled; the result is a series of pulses based on the sampled data.

pulse code modulation (PCM) A technique that modifies PAM pulses to create a digital signal.

pulse stuffing In TDM, a technique that adds dummy bits to the input lines with lower rates.

pure ALOHA The original ALOHA.

Q

quadrature amplitude modulation (QAM) A digital-to-analog modulation method in which the phase and amplitude of the carrier signal vary with the modulating signal.

quality of service (QoS) A set of attributes related to the performance of the connection.

quantization The assignment of a specific range of values to signal amplitudes.

quantization error Error introduced in the system during quantization (analog-to-digital conversion).

queue A waiting list.

R

radio wave Electromagnetic energy in the 3-KHz to 300-GHz range.

random access A medium access category in which each station can access the medium without being controlled by any other station.

ranging In an HFC network, a process that determines the distance between the CM and the CMTS.

rate adaptive asymmetrical digital subscriber line (RADSL) A DSL-based technology that features different data rates depending on the type of communication.

read-only memory (ROM) Permanent memory with contents that cannot be changed.

Real-Time Streaming Protocol (RTSP) An out-of-band control protocol designed to add more functionality to the streaming audio/video process.

Real-time Transport Control Protocol (RTCP) A companion protocol to RTP with messages that control the flow and quality of data and allow the recipient to send feedback to the source or sources.

Real-time Transport Protocol (RTP) A protocol for real-time traffic; used in conjunction with UDP.

reconciliation sublayer A Fast Ethernet sublayer which passes data in 4-bit format to the MII.

recursive resolution Resolution of the IP address in which the client sends its request to a server that eventually returns a response.

redundancy The addition of bits to a message for error control.

Reed-Solomon A complex, but efficient, cyclic code.

reflection The phenomenon related to the bouncing back of light at the boundary of two media.

refraction The phenomenon related to the bending of light when it passes from one medium to another.

regional ISP A small ISP that is connected to one or more NSPs.

registrar An authority to register new domain names.

relay agent For BOOTP, a router that can help send local requests to remote servers.

reliability A QoS flow characteristic; dependability of the transmission.

remote bridge A device that connects LANs and point-to-point networks; often used in a backbone network.

rendezvous router A router that is the core or center for each multicast group; it becomes the root of the tree.

rendezvous-point tree A group-shared tree method in which there is one tree for each group.

repeater A device that extends the distance a signal can travel by regenerating the signal.

replay attack The resending of a message that has been intercepted by an intruder.

Request for Comment (RFC) A formal Internet document concerning an Internet issue.

resolver The DNS client that is used by a host that needs to map an address to a name or a name to an address.

Resource Reservation Protocol (RSVP) A signaling protocol to help IP create a flow and make a resource reservation to improve QoS.

retransmission time-out The expiration of a timer that controls the retransmission of packets.

return to zero (RZ) A digital-to-digital encoding technique in which the voltage of the signal is zero for the second half of the bit interval.

reuse factor In cellular telephony, the number of cells with a different set of frequencies.

Reverse Address Resolution Protocol (RARP) A TCP/IP protocol that allows a host to find its Internet address given its physical address.

reverse path broadcasting (RPB) A technique in which the router forwards only the packets that have traveled the shortest path from the source to the router.

reverse path forwarding (RPF) A technique in which the router forwards only the packets that have traveled the shortest path from the source to the router.

reverse path multicasting (RPM) A technique that adds pruning and grafting to RPB to create a multicast shortest path tree that supports dynamic membership changes.

Rijndael algorithm An algorithm named after its two Belgian inventors, Vincent Rijmen and Joan Daemen that is the basis of AES.

ring topology A topology in which the devices are connected in a ring. Each device on the ring receives the data unit from the previous device, regenerates it, and forwards it to the next device.

Rivest, Shamir, Adleman (RSA) encryption See *RSA encryption*.

RJ45 A coaxial cable connector.

roaming In cellular telephony, the ability of a user to communicate outside of his own service provider's area.

root server In DNS, a server whose zone consists of the whole tree. A root server usually does not store any information about domains but delegates its authority to other servers, keeping references to those servers.

rotary dialing Accessing the switching station through a phone that sends a digital signal to the end office.

rotation cipher A keyed or keyless cipher in which the input bits are rotated to the left or right to create output bits.

round-trip time (RTT) The time required for a datagram to go from a source to a destination and then back again.

route A path traveled by a packet.

router An internetworking device operating at the first three layers. A router is attached to two or more networks and forwards packets from one network to another.

routing The process performed by a router; finding the next hop for a datagram.

Routing Information Protocol (RIP) A routing protocol based on the distance vector routing algorithm.

routing table A table containing information a router needs to route packets. The information may include the network address, the cost, the address of the next hop, and so on.

RSA cryptosystem A popular public-key encryption method developed by Rivest, Shamir, and Adleman.

S

sampling The process of obtaining amplitudes of a signal at regular intervals.

sampling rate The number of samples obtained per second in the sampling process.

satellite network A combination of nodes that provides communication form one point on the earth to another.

S-box An encryption device made of decoders, P-boxes, and encoders.

scatternet A combination of piconets.

scrambling In digital-to-digital conversion, modifying part of the rules in line coding scheme to create bit synchronization.

secondary station In the poll/select access method, a station that sends a response in answer to a command from a primary station.

secret-key encryption A security method in which the key for encryption is the same as the key for decryption; both sender and receiver have the same key.

Secure Hash Algorithm 1 (SHA-1) A hash algorithm designed by the National Institute of Standards and Technology (NIST). It was published as a Federal Information Processing Standard (FIPS).

Secure Socket Layer (SSL) A protocol designed to provide security and compression services to data generated from the application layer.

Security Association (SA) An IPSec protocol that creates a logical connection between two hosts.

security association database (SADB) A database defining a set of single security associations.

security parameter index (SPI) A parameter that uniquely distinguish one security association from the others.

segment The packet at the TCP layer. Also, the length of transmission medium shared by devices.

segmentation The splitting of a message into multiple packets; usually performed at the transport layer.

segmentation and reassembly (SAR) The lower AAL sublayer in the ATM protocol in which a header and/or trailer may be added to produce a 48-byte element.

select In the poll/select access method, a procedure in which the primary station asks a secondary station if it is ready to receive data.

selective-repeat ARQ An error-control method in which only the frame in error is resent.

self-synchronization Synchronization of long strings of 1s or 0s through the coding method.

semantics The meaning of each section of bits.

sequence number The number that denotes the location of a frame or packet in a message.

serial transmission Transmission of data one bit at a time using only one single link.

server A program that can provide services to other programs, called clients.

server control point (SCP) In SS7 terminology, the node that controls the whole operation of the network.

Session Initiation Protocol (SIP) In voice over IP, an application protocol that establishes, manages, and terminates a multimedia session.

session layer The fifth layer of the OSI model, responsible for the establishment, management, and termination of logical connections between two end users.

setup phase In virtual circuit switching, a phase in which the source and destination use their global addresses to help switches make table entries for the connection.

Shannon capacity The theoretical highest data rate for a channel.

shielded twisted-pair (STP) Twisted-pair cable enclosed in a foil or mesh shield that protects against electromagnetic interference.

shift cipher The simplest monoalphabetic cipher in which the plaintext and ciphertext consist of letters. In the encryption algorithm, the characters are shifted down the character list; in the decryption algorithm, the characters are shifted up the character list.

shift register A register in which each memory location, at a time click, accepts the bit at its input port, stores the new bit, and displays it on the output port.

short interframe space (SIFS) In CSMA/CA, a period of time that the destination waits after receiving the RTS.

shortest path tree A routing table formed by using the Dijkstra algorithm.

signaling connection control point (SCCP) In SS7, the control points used for special services such as 800 calls.

signal element The shortest section of a signal (time-wise) that represents a data element.

signal point (SP) In SS7 terminology, the user telephone or computer is connected to the signal points.

signal rate The number of signal elements sent in one second.

signal transport port (STP) In SS7 terminology, the node used by the signaling network.

Signaling System Seven (SS7) The protocol that is used in the signaling network.

signal-to-noise ratio (SNR) The ratio of average signal power to average noise power.

silly window syndrome A situation in which a small window size is advertised by the receiver and a small segment sent by the sender.

simple and efficient adaptation layer (SEAL) An AAL layer designed for the Internet (AAL5).

simple bridge A networking device that links two segments; requires manual maintenance and updating.

Simple Mail Transfer Protocol (SMTP) The TCP/IP protocol defining electronic mail service on the Internet.

Simple Network Management Protocol (SNMP) The TCP/IP protocol that specifies the process of management in the Internet.

Simple Protocol The simple protocol we used to show an access method without flow and error control.

simplex mode A transmission mode in which communication is one way.

sine wave An amplitude-versus-time representation of a rotating vector.

single-bit error Error in a data unit in which only one single bit has been altered.

single-mode fiber An optical fiber with an extremely small diameter that limits beams to a few angles, resulting in an almost horizontal beam.

site local address An IPv6 address for a site having several networks but not connected to the Internet.

SKEME A protocol for key exchange designed by Hugo Krawcyzk. It is one of the three protocols that form the basis of IKE.

sky propagation Propagation of radio waves into the ionosphere and then back to earth.

slash notation A shorthand method to indicate the number of 1s in the mask.

sliding window A protocol that allows several data units to be in transition before receiving an acknowledgment.

sliding window ARQ An error-control protocol using sliding window concept.

slotted ALOHA The modified ALOHA access method in which time is divided into slots and each station is forced to start sending data only at the beginning of the slot.

slow convergence A RIP shortcoming apparent when a change somewhere in the internet propagates very slowly through the rest of the internet.

slow start A congestion-control method in which the congestion window size increases exponentially at first.

socket address A structure holding an IP address and a port number.

source quench A method, used in ICMP for flow control, in which the source is advised to slow down or stop the sending of datagrams because of congestion.

source routing Explicitly defining the route of a packet by the sender of the packet.

source routing bridge A source or destination station that performs some of the duties of a transparent bridge as a method to prevent loops.

source-based tree A tree used for multicasting by multicasting protocols in which a single tree is made for each combination of source and group.

source-to-destination delivery The transmission of a message from the original sender to the intended recipient.

space propagation A type of propagation that can penetrate the ionosphere.

space-division switching Switching in which the paths are separated from each other spatially.

spanning tree A tree with the source as the root and group members as leaves; a tree that connects all of the nodes.

spatial compression Compressing an image by removing redundancies.

spectrum The range of frequencies of a signal.

split horizon A method to improve RIP stability in which the router selectively chooses the interface from which updating information is sent.

spread spectrum A wireless transmission technique that requires a bandwidth several times the original bandwidth.

Standard Ethernet The conventional Ethernet operating at 10 Mbps.

star topology A topology in which all stations are attached to a central device (hub).

start bit In asynchronous transmission, a bit to indicate the beginning of transmission.

state transition diagram A diagram to illustrate the states of a finite state machine.

static document On the World Wide Web, a fixed-content document that is created and stored in a server.

static mapping A technique in which a list of logical and physical address correspondences is used for address resolution.

static routing A type of routing in which the routing table remains unchanged.

stationary host A host that remains attached to one network.

statistical TDM A TDM technique in which slots are dynamically allocated to improve efficiency.

status line In the HTTP response message a line that consists of the HTTP version, a space, a status code, a space, a status phrase.

stop bit In asynchronous transmission, one or more bits to indicate the end of transmission.

stop-and-wait ARQ An error-control protocol using stop-and-wait flow control.

Stop-and-Wait Protocol A protocol in which the sender sends one frame, stops until it receives confirmation from the receiver, and then sends the next frame.

store-and-forward switch A switch that stores the frame in an input buffer until the whole packet has arrived.

- straight tip connector** A type of fiber-optic cable connector using a bayonet locking system.
- Stream Control Transmission Protocol (SCTP)** The transport layer protocol designed for Internet telephony and related applications.
- streaming live audio/video** Broadcast data from the Internet that a user can listen to or watch.
- streaming stored audio/video** Data downloaded as files from the Internet that a user can listen to or watch.
- strong collision** Creating two message with the same digest.
- Structure of Management Information (SMI)** In SNMP, a component used in network management.
- STS multiplexer/demultiplexer** A SONET device that multiplexes and demultiplexes signals.
- stub link** A network that is connected to only one router.
- subnet** subnetwork.
- subnet address** The network address of a subnet.
- subnet mask** The mask for a subnet.
- subnetwork** A part of a network.
- subscriber channel connector** A fiber-optic cable connector using a push/pull locking mechanism.
- substitution cipher** A bit-level encryption method in which n bits substitute for another n bits as defined by P-boxes, encoders, and decoders.
- suffix** For a network, the varying part (similar to the hostid) of the address. In DNS, a string used by an organization to define its host or resources.
- summary link to AS boundary router LSA** An LSA packet that lets a router inside an area know the route to an autonomous boundary router.
- summary link to network LSA** An LSA packet that finds the cost of reaching networks outside of the area.
- supergroup** A signal composed of five multiplexed groups.
- supernet** A network formed from two or more smaller networks.
- supernet mask** The mask for a supernet.
- switch** A device connecting multiple communication lines together.
- switched Ethernet** An Ethernet in which a switch, replacing the hub, can direct a transmission to its destination.
- switched virtual circuit (SVC)** A virtual circuit transmission method in which a virtual circuit is created and in existence only for the duration of the exchange.
- switched/56** A temporary 56-Kbps digital connection between two users.
- switching office** The place where telephone switches are located.
- symmetric digital subscriber line (SDSL)** A DSL-based technology similar to HDSL, but using only one single twisted-pair cable.
- symmetric-key cryptography** A cipher in which the same key is used for encryption and decryption.
- synchronization points** Reference points introduced into the data by the session layer for the purpose of flow and error control.

synchronous connection oriented (SCO) link In a Bluetooth network, a physical link created between a master and a slave that reserves specific slots at regular intervals.

Synchronous Digital Hierarchy (SDH) The ITU-T equivalent of SONET.

Synchronous Optical Network (SONET) A standard developed by ANSI for fiber optic technology that can transmit high-speed data. It can be used to deliver text, audio, and video.

synchronous payload envelope (SPE) The part of the SONET frame containing user data and transmission overhead.

synchronous TDM A TDM technique in which each input has an allotment in the output even when it is not sending data.

synchronous transmission A transmission method that requires a constant timing relationship between the sender and the receiver.

synchronous transport module (STM) A signal in the SDH hierarchy.

synchronous transport signal (STS) A signal in the SONET hierarchy.

syndrome A sequence of bit generated by applying the error checking function to a codeword.

syntax The structure or format of data, meaning the order in which they are presented.

T

T lines A hierarchy of digital lines designed to carry speech and other signals in digital forms. The hierarchy defines T-1, T-2, T-3, and T-4 lines.

tandem office The toll office in a telephone network.

TCP/IP protocol suite A five-layer protocol suite that defines the exchange of transmissions across the Internet.

teardown phase In virtual circuit switching, the phase in which the source and destination inform the switch to erase their entry.

telecommunications Exchange of information over distance using electronic equipment.

teleconferencing Audio and visual communication between remote users.

Teledesic A system of satellites that provides fiber-optic communication (broadband channels, low error rate, and low delay)

telephone user port (TUP) A protocol at the upper layer of SS7 that is responsible for setting up voice calls.

temporal compression An MPEG compression method in which redundant frames are removed.

Ten-Gigabit Ethernet The new implementation of Ethernet operating at 10 Gbps.

Terminal Network (TELNET) A general purpose client-server program that allows remote login.

three-way handshaking A sequence of events for connection establishment or termination consisting of the request, then the acknowledgment of the request, and then confirmation of the acknowledgment.

throughput The number of bits that can pass through a point in one second.

ticket-granting server (TGS) A Kerberos server that issues tickets.

time division duplexing TDMA (TDD-TDMA) In a Bluetooth network, a kind of half-duplex communication in which the slave and receiver send and receive data, but not at the same time (half-duplex).

time division multiple access (TDMA) A multiple access method in which the bandwidth is just one time-shared channel.

time to live (TTL) The lifetime of a packet.

time-division multiplexing (TDM) The technique of combining signals coming from low-speed channels to share time on a high-speed path.

time-division switching A circuit-switching technique in which time-division multiplexing is used to achieve switching.

time-domain plot A graphical representation of a signal's amplitude versus time.

time-slot interchange (TSI) A time-division switch consisting of RAM and a control unit.

token A small packet used in token-passing access method.

token bucket An algorithm that allows idle hosts to accumulate credit for the future in the form of tokens.

token passing An access method in which a token is circulated in the network. The station that captures the token can send data.

Token Ring A LAN using a ring topology and token-passing access method.

topology The structure of a network including physical arrangement of devices.

traffic control A method for shaping and controlling traffic in a wide area network.

traffic shaping A mechanism to control the amount and the rate of the traffic sent to the network to improve QoS.

trailer Control information appended to a data unit.

transaction capabilities application port (TCAP) A protocol at the upper layer of SS7 that provides remote procedure calls that let an application program on a computer invoke a procedure on another computer.

transceiver A device that both transmits and receives.

transient link A network with several routers attached to it.

Transmission Control Protocol (TCP) A transport protocol in the TCP/IP protocol suite.

Transmission Control Protocol/Internetworking Protocol (TCP/IP) A five-layer protocol suite that defines the exchange of transmissions across the Internet.

transmission medium The physical path linking two communication devices.

transmission rate The number of bits sent per second.

transparency The ability to send any bit pattern as data without it being mistaken for control bits.

transparent bridge Another name for a learning bridge.

transparent data Data that can contain control bit patterns without being interpreted as control.

transport layer The fourth layer in the Internet and OSI model; responsible for reliable end-to-end delivery and error recovery.

Transport Layer Security (TLS) The IETF standard version of SSL. The two are very similar, with slight differences.

transposition cipher A character-level encryption method in which the position of the character changes.

trellis-coded modulation A modulation technique that includes error correction.

trilateration A two-dimensional method of finding a location given the distances from 3 different points.

triple DES An algorithm compatible with DES that uses three DES blocks and two 56-bit keys.

Trivial File Transfer Protocol (TFTP) An unreliable TCP/IP protocol for file transfer that does not require complex interaction between client and server.

trunk Transmission media that handle communications between offices.

tunneling In multicasting, a process in which the multicast packet is encapsulated in a unicast packet and then sent through the network. In VPN, the encapsulation of an encrypted IP datagram in a second outer datagram. For IPv6, a strategy used when two computers using IPv6 want to communicate with each other when the packet must pass through a region that uses IPv4.

twisted-pair cable A transmission medium consisting of two insulated conductors in a twisted configuration.

two-dimensional parity check An error detection method in two dimensions.

type of service (TOS) A criteria or value that specifies the handling of the datagram.

U

unbalanced configuration An HDLC configuration in which one device is primary and the others secondary.

unguided medium A transmission medium with no physical boundaries.

unicast address An address belonging to one destination.

unicast routing The sending of a packet to just one destination.

unicasting The sending of a packet to just one destination.

Unicode The international character set used to define valid characters in computer science.

unidirectional antenna An antenna that sends or receives signals in one direction.

Uniform Resource Locator (URL) A string of characters (address) that identifies a page on the World Wide Web.

unipolar encoding A digital-to-digital encoding method in which one nonzero value represents either 1 or 0; the other bit is represented by a zero value.

unshielded twisted-pair (UTP) A cable with wires that are twisted together to reduce noise and crosstalk. See also *twisted-pair cable* and *shielded twisted-pair*.

unspecified bit rate (UBR) The data rate of an ATM service class specifying only best-effort delivery.

uplink Transmission from an earth station to a satellite.

uploading Sending a local file or data to a remote site.

user agent (UA) An SMTP component that prepares the message, creates the envelope, and puts the message in the envelope.

user authentication A security measure in which the sender identity is verified before the start of a communication.

user datagram The name of the packet in the UDP protocol.

User Datagram Protocol (UDP) A connectionless TCP/IP transport layer protocol.

user network interface (UNI) The interface between a user and the ATM network.

user support layers The session, presentation, and application layers.

user-to-network interface (UNI) In ATM, the interface between an end point (user) and an ATM switch.

V

V series ITU-T standards that define data transmission over telephone lines. Some common standards are V.32, V.32bis, V.90, and V92.

variable bit rate (VBR) The data rate of an ATM service class for users needing a varying bit rate.

very high bit rate digital subscriber line (VDSL) A DSL-based technology for short distances.

video Recording or transmitting of a picture or a movie.

Vigenere cipher A polyalphabetic substitution scheme that uses the position of a character in the plaintext and the character's position in the alphabet.

virtual circuit (VC) A logical circuit made between the sending and receiving computer.

virtual circuit switching A switching technique used in switched WANs.

virtual link An OSPF connection between two routers that is created when the physical link is broken. The link between them uses a longer path that probably goes through several routers.

virtual local area network (VLAN) A technology that divides a physical LAN into virtual workgroups through software methods.

virtual private network (VPN) A technology that creates a network that is physically public, but virtually private.

virtual tributary (VT) A partial payload that can be inserted into a SONET frame and combined with other partial payloads to fill out the frame.

Voice Over Frame Relay (VOFR) A Frame Relay option that can handle voice data.

voice over IP A technology in which the Internet is used as a telephone network.

W

Walsh table In CDMA, a two-dimensional table used to generate orthogonal sequences.

wave-division multiplexing (WDM) The combining of modulated light signals into one signal.

wavelength The distance a simple signal can travel in one period.

weak collision Given a digest, creating a second message with the same digest.

web page A unit of hypertext or hypermedia available on the Web.

weighted fair queueing A packet scheduling technique to improve QoS in which the packets are assigned to queues based on a given priority number.

well-known port number A port number that identifies a process on the server.

wide area network (WAN) A network that uses a technology that can span a large geographical distance.

wide area telephone service (WATS) A telephone service in which the charges are based on the number of calls made.

World Wide Web (WWW) A multimedia Internet service that allows users to traverse the Internet by moving from one document to another via links that connect them together.

1106 GLOSSARY

X

X.25 An ITU-T standard that defines the interface between a data terminal device and a packet-switching network

X.509 An ITU-T standard for public key infrastructure (PKI)

Z

zone In DNS, what a server is responsible for or has authority over.

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INDEX

Numerics

- 1000Base-CX, 414
- 1000Base-LX, 414
- 1000Base-SX, 414
- 1000Base-T, 414
- 100Base-FX, 410–411
- 100Base-T4, 410, 412
- 100Base-TX, 410–411
- 10Base2, 404
- 10Base5, 403
- 10Base-F, 405
- 10Base-T, 404
 - full-duplex, 408
- 10GBase-E, 416
- 10GBase-L, 416
- 10GBase-S, 416
- 2B1Q, 111
 - HDSL, 255
- 3DES. *See* Triple DES
- 4B/5B, 116
- 4D-PAM5, 113
 - Gigabit Ethernet, 415
- 56K modem, 250
 - ADSL, 252
- 5-slot frame, 439
- 800 service, 247
- 802.11, 428
- 8B/10B, 118
 - Gigabit Ethernet, 415
- 8B/6T code, 1055
- 8B6T, 112
- 900 service, 247

A

- AA battery, 60
- AAL, 532
- AAL1, 532
- AAL2, 532
- AAL3/4, 534
- AAL5, 535
- ABM, 341
- AC value, 905
- access, 363
- access control
 - data link layer, 35
- access point. *See* AP

access rate, 787

accounting management, 877

ACK, 724

duplicate, 732

in poll, 381

Selective Repeat ARQ, 339

ACK frame, 318

ACK message, 921

acknowledgement number,
319, 719

acknowledgement policy, 766

acknowledgment, 731

circuit switching, 217–218

CSMA/CA, 378

flow control, 311

Go-Back-N, 326

virtual-circuit network, 225

ACL, 439

active document, 860

active open, 723

ad hoc architecture

network, 421

additive increase, 770

address, 1061

IP, 47

link, 46

logical, 36

need for multiple, 612

physical, 46

port, 49

service-point, 38, 701

types, 45, 52

virtual-circuit network, 222

address aggregation,

561, 652

address allocation, 561

address block, 555

address field

HDLC, 342

address mask

ICMPv6, 640

address mask message, 626

address resolution protocol.

See ARP

address space, 550

address to name

resolution, 807

addressing, 45

circuit switching, 215

Ethernet, 400

VPN, 1007

admission, 781

admission control, 780

admission policy, 766

ADSL, 252–253, 255

adaptive, 252

DMT, 254

downstream data and
control, 253

HDSL, 255

idle channels, 252

local loop, 252

upstream data and control,
253

VDSL, 255

voice, 252

ADSL Lite, 254

Advanced Encryption

Standard. *See* AES

Advanced Mobile Phone
System. *See* AMPS

Advanced Research Projects
Agency. *See* ARPA

AES, 943

configurations, 944

round, 944

structure, 944

AF PHB, 786

agent, 877–878

database, 878

function, 891

MIB, 886

passive open, 895

trap, 878

AH protocol, 998

authentication data

field, 999

ESP, 1001

next header field, 999

sequence number, 999

SPI field, 999

AL field, 534

alias, 831

Alice, 932

allocation of resources, 745

ALOHA, 365

collision, 365

pure ALOHA, 365

vulnerable time, 367

alternate mark inversion.

See AMI

AM, 153–155

bandwidth, 153–154

carrier, 153

AM bandwidth, 153

AM radio, 71, 167

AM station, 154

American National Standards
Institute. *See* ANSI

American Standard Code for
Information Interchange.
See ASCII

AMI, 110

B8ZS, 119

HDSL, 255

synchronization, 111

amplifier, 447

attenuation, 81

cable TV, 256

amplitude, 142, 144

ASK, 143

FM, 154

FSK, 146

measurement, 59

PM, 155

PSK, 148

sine wave, 65

amplitude modulation. *See* AM

amplitude shift keying.
See ASK

AMPS, 470

analog data, 57

analog hierarchy

telephone system, 165

analog leased service,

165, 247

analog service, 247

analog signal, 57–58,

101, 120

digitize, 120

periodic, 59

1112 INDEX

- analog switched service, 247
 analog transmission, 141
 T line, 177
 analog TV, 71
 analog-to-analog conversion,
 141, 152
 analog-to-digital
 conversion, 101
 AND operation, 557
 angle of incidence, 198
 anonymous FTP, 844
 ANSI, 20
 antenna
 focus, 206
 horn, 207
 line-of-sight, 203
 parabolic dish, 207
 satellite, 480
 anti-jamming, 183
 anycast address, 570
 AP, 421
 APNIC, 569
 applet, 860
 application adaptation layer.
 See AAL
 application layer, 41
 directory services, 42
 file manipulation, 42
 mail services, 42
 NVT, 41
 responsibilities, 41, 795
 services, 41
 TCP/IP, 42, 45
 architecture
 e-mail, 824
 OSI model, 30
 area, 671
 area border router, 671
 ARP, 43–44, 613
 broadcast query, 612
 encapsulation, 615
 four cases, 615
 hardware length field, 614
 hardware type field, 614
 host to host on different
 networks, 616
 host to host on single
 network, 615
 ICMPv6, 596, 640
 operation, 615
 operation field, 614
 packet components, 612
 packet format, 613
 process, 615
 protocol length field, 614
 protocol type field, 614
 proxy, 617
- query packet, 612
 response packet, 612
 response packet
 components, 612
 router to host on different
 networks, 616
 router to host on same
 network, 616
 sender hardware address
 field, 614
 sender protocol address
 field, 614
 target hardware address
 field, 614
 target protocol address
 field, 614
 unicast response, 612
- ARPA, 17
 ARPANET, 17
 ARQ, 311
 AS, 659, 984
 graphical
 representation, 673
 multihomed, 677
 speaker node, 674
 stub, 676
 transit, 677
 types, 676
- ASCII, 5, 628, 1029
 character code table, 1032
- ASK, 142
 bandwidth, 144, 146
 binary, 144
 carrier signal, 143
 constellation, 151
 implementation, 144
 multilevel, 145
 with PSK, 152
- ASN.1, 989
 simple type examples, 883
 SMI, 882
- ASP, 859
 association, 737, 743
 termination, 748
- asymmetric
 cryptography, 932
 asymmetrical DSL.
 See ADSL
- asymmetric-key
 cryptography, 933
 keys, 933
- asynchronous balanced mode.
 See ABM
- asynchronous connectionless
 link. *See ACL*
- asynchronous TDM
 ATM, 525
- asynchronous
 transmission, 133–134
- Asynchronous Transmission
 Mode. *See ATM*
- AT&T Bell System, 1059
 AT&T divestiture, 1059
 ATM, 227, 308, 523,
 526–527
 AAL1, 532
 AAL2, 532
 AAL3/4, 534
 AAL5, 535
 architecture, 526
 asynchronous TDM, 525
 ATM layer, 530
 available bit rate class, 789
 backward compatibility, 523
 cell, 527
 cell delay variation, 790
 cell error ratio, 790
 cell loss ratio, 790
 cell transfer delay, 790
 cell variation delay
 tolerance, 790
 connection
 establishment, 528
 connection release, 528
 connection types, 536
 connection-oriented, 538
 connections, 528
 constant bit rate class, 789
 design goals, 523
 example, 526
 header for NNI, 531
 hierarchical routing, 527
 Identifier, 527
 Information Super-
 Highway, 523
 layers, 529
 minimum cell rate, 790
 multimedia, 536
 multiplexing, 525
 network-related
 attributes, 790
 peak cell rate, 790
 physical layer, 530
 QoS, 789
 SONET, 530
 sustained cell rate, 790
 SVC, 529
 switching, 529
 switching fabric, 529
 unspecified bit rate class, 789
 user-related attributes, 790
 variable bit rate class, 789
 variable bit rate non-real
 time, 789
- variable bit rate nonreal
 time, 789
- variable bit rate
 real-time, 789
- virtual connection, 526
 WAN, 536
 ATM Forum, 523
 address, 1061
 ATM LAN, 536
 advantages, 536
 architecture, 536
 BUS, 539
 client/server, 540
 expansion, 536
 LANE, 538
 legacy, 536
 mixed architecture, 537
 pure, 536
 ATM layer, 529
 cell loss priority, 532
 cell size, 530
 congestion control, 532
 function, 530
 generic flow control, 531
 header error
 correction, 532
- header for UNI, 531
 header format, 531
 NNI level flow control, 531
 payload type, 531
 UNI level flow control, 531
 VCI field, 531
 VPI, 531
 VPI field, 531
- ATM switch, 536
 attenuation, 81, 446
 amplifier, 81
 optical fiber, 202
- attribute, 856
 audio
 compression, 903
 audio signal, 902
 authentication, 349
 AH protocol, 1000
 Diffie-Hellman, 956
 entity, 962
 IPv6, 567, 596
 message, 962
 packet, 349
 PPP, 352
 authentication data, 999
 authentication extension
 header, 602
- Authentication Header
 protocol. *See AH protocol*
 authentication serve. *See AS*
 authentication state, 349

- automatic repeat request.
See ARQ
- autonegotiation, 409
- autonomous system, 671.
See also AS
- average data rate, 762
- B**
- B8ZS, 118
- backbone, 671
- area id, 671
 - bus, 11
 - logical bus, 456
 - logical star, 457
 - virtual link, 671
- backbone network, 456
- backbone router, 671
- backoff strategy
- CSMA/CA, 378
- backoff time, 366
- backward explicit
- congestion notification.
See BECN
- backward signal, 768
- band, 204
- AMPS, 470
 - Bluetooth, 437
 - D-AMPS, 471
 - GSM, 472
 - IS-95, 474
- band-limited signal, 1049
- band-pass channel, 79, 141
- low-pass, 79
- bandwidth, 69, 89, 103, 143, 154, 248, 518
- AM, 153–154
 - AM radio, 154, 167
 - ASK, 144, 146
 - audio signal, 154–155
 - baud rate, 104
 - BFSK, 146
 - bit rate, 78
 - BPSK, 149
 - bridge, 406
 - cellular telephone, 167
 - digital signal, 74
 - digital signal
 - approximation, 77
- effective, 104
- Ethernet, 406
- FDM, 162
- flow characteristic, 776
- FM, 154–155
- FM requirement, 154
- group, 166
- in bps, 89
- in hertz, 89
- infinite, 74
- local loop, 242
- master group, 166
- minimum, 104
- non-periodic signal, 69
- NRZ-I and NRZ-L, 108
- optical fiber, 202
- periodic signal, 69
- PM, 156
- QAM, 152
- real-time traffic, 915
 - supergroup, 166
 - telephone line, 248
 - throughput, 90
 - transmission time, 91
- bandwidth on demand
- bursty data, 518
- bandwidth-delay product, 92, 322
- banyan switch, 233
- internal collision, 235
- Barker sequence, 184
- base, 1050
- base 10, 1051
- base 256, 1037, 1040
- to binary, 1042
 - weight and value, 1040
- base e, 1051
- base header, 597
- base station (BS), 467
- base transformation, 1052
- baseband layer, 437
- baseband transmission, 75
- approximation, 78
- baseline, 104
- baseline wandering, 104
- Manchester, 109
 - NRZ-L, 107
- Basic Encoding Rules.
See BER
- Basic Latin, 1029
- basic multilingual plane (BMP), 1030
- basic service set.
See BSS
- BA size, 534
- Batcher, 235
- Batcher-banyan switch, 235
- baud rate, 103, 142
- and bit rate, 142
 - bandwidth, 104
- Bc, 787
- Be, 788
- beacon frame, 426
- BECN, 521
- mechanism, 773
 - sender, 773
- Bell Operating Company.
See BOC
- BER, 884
- class subfield, 884
 - format, 884
 - format subfield, 884
 - integer example, 885
 - length field, 885
 - number subfield, 884
 - SNMP, 893
 - tag field, 884
 - value field, 885
- best-effort delivery, 44, 583
- B-frame, 908
- BFSK, 146
- BGP, 659, 676
- external, 677
 - internal, 677
 - path attributes, 677
 - path vector routing, 676
 - port, 1065
 - session, 677
- bidirectional edge, 673
- bidirectional frame, 908
- binary ASK, 144
- binary exponential backoff, 366
- binary notation, 550
- finding the class, 552
- binary number, 1038–1040
- binary PSK, 148
- symbols, 1038–1039
 - to base 256, 1042
 - to hexadecimal, 1041
 - weight and value, 1038
- binary system, 1037–1038
- biphase coding, 109
- bipolar AMI, 110
- bipolar coding, 110
- bit, 102
- bit padding, 174, 176
- bit rate, 73, 103, 142
- and baud rate, 142
 - bandwidth, 78
- bit stuffing, 174, 310
- bit-oriented cipher, 938
- bit-oriented protocol, 309
- bits per second, 73
- block, 555
- message digest, 968
- block code
- error correction, 277
 - linear, 277
 - minimum Hamming distance, 276
 - non-linear, 277
- block coding, 115, 269
- 8B/10B, 118
- combination, 115
- division, 115
- error correction, 273
- error detection, 272
- substitution, 115
- block descriptor, 843
- block processing
- RIPEMD-160, 968
- blocking, 229
- Blowfish, 945
- Bluetooth, 421, 434
- applications, 434
 - architecture, 435
 - device, 436
 - frame format, 439
 - layers, 436
- Bluetooth LAN, 435
- BNC connector, 196
- Bob, 932
- BOC, 1059
- BOOTP, 618–619
- binding, 620
 - relay agent, 619
 - static configuration
 - protocol, 620
 - static protocol, 620
- Border Gateway Protocol.
See BGP
- BPSK, 148
- constellation, 151
 - implementation, 149
 - QPSK, 149
- bridge, 406, 447
- as a filter, 448
 - collision domain, 407
 - connecting LANs, 454
 - dynamic, 449
 - Ethernet, 406
 - function, 406, 447
 - loop problem, 450
 - multiple LAN issues, 454
 - redundant, 450
 - source routing, 454
 - transparent, 449
- bridge protocol data unit (BPDU), 452
- bridged Ethernet, 406
- broadcast address
- Ethernet, 400
- broadcast/unknown server.
See bus
- broadcasting, 680
- VLAN, 460
- browser, 852
- client protocol, 852

- browser—*Cont.*
 controller, 852
 dynamic document, 857
 HTML, 855
 interpreter, 852
 markup language, 855
 streaming stored audio/video, 909
- BSS, 421
 BSS-transition mobility, 423
 Btag, 534
 bucket brigade attack, 956
 buffer
 circular, 717
 flow control, 311
 message digest, 968
 packet switch, 232
 receiver site, 717
 sender site, 717
 TCP, 717
 buffer allocation, 534
 burst, 267
 burst error, 267–268
 2 single-bit errors, 296
 example, 268
 bursty data, 518
 Frame Relay, 518
 T-line, 518
 traffic control, 788
 bursty flow, 763
 bursty traffic
 leaky bucket, 779
 token bucket, 779
 bus, 9, 11–12
 advantages, 11
 backbone, 11
 disadvantages, 12
 drop lines, 11
 fault, 12
 tap, 11
 bus ring topology, 382
 bus topology, 34
 BYE message, 921
 byte number, 719
 byte stuffing, 308
 byte synchronization, 135
 byte-oriented protocol, 736
 byte-stuffing, 349
- C**
 CA, 987, 992
 cable
 coaxial, 195
 twisted-pair, 193
 cable modem. *See CM*
 cable modem transmission system. *See CMTS*
- cable network, 241
 cable TV, 256
 coaxial cable, 197
 head end, 256
 caching, 808
 counter, 809
 problems, 809
 time-to-live, 809
 unauthoritative source, 809
- Caesar Cipher, 936
 CANCEL message, 921
 capacities, 178, 876
 carrier, 79, 370
 AM, 153–154
 FM, 154–155
 inter-LATA, 243
 PM, 155
 carrier division multiple access. *See CDMA*
 carrier extension, 413
 carrier frequency, 143–144
 carrier sense multiple access.
 See CSMA
 carrier sense multiple access with collision avoidance.
 See CSMA/CA
 carrier sense multiple access with collision detection.
 See CSMA/CD
 carrier signal, 143
 ASK, 143
 cascading, 82
 case factor, 103
 CAST-128, 945
 CATV, 256
 CBC, 946
 characteristics, 947
 CBT, 690
 autonomous system, 690
 core router, 691
 DVMRP and MOSPF, 690
 encapsulation, 691
 leaving the group, 690
 multicast packet, 691
 rendezvous router, 690
- CCITT, 20
 CCK, 434
 CDMA, 162, 383, 385,
 474–475, 478
 encoding, 387
 sequence generation, 389
- CDMA multiplexer, 475
 CDMA2000, 478
 cell, 524, 527–528, 790
 ATM, 527
 definition, 524
 header, 528
- payload, 527
 size, 527
 structure, 528
 cell network, 524
 concept, 524
 example, 525
 multiplexing, 524
 real-time transmission, 525
 stream, 525
 vs framenetwork, 524
- cell relay, 523
 cellular telephone, 167
 cellular telephony, 467
 first generation, 469
 handoff, 469
 MSC, 469
 placing a call, 468
 query signal, 469
 radius, 467
 receiving a call, 469
 second generation, 470
 third generation, 477
 tracking, 467
 transmission power, 467
 weak signal, 469
- center router, 684
 Cerf, Vint, 17
 certification authority.
 See CA
- CFB, 947
 CGI, 857
 body, 859
 form, 858
 header, 859
 output, 859
 parameter passing, 858
 query string, 858
- Challenge Handshake Authentication Protocol.
 See CHAP
- channel, 8, 162
 channel identifier, 533
 channelization, 383
 channels
 FDM, 162
- CHAP, 352
 packet types, 353
 password, 353
 security, 353
 three-way handshake, 352
- character-oriented cipher, 938
 character-oriented protocol, 308
 Cheapernet. *See 10Base2*
 checksum, 298, 711, 731
 as hash function, 967
 example, 594
- examples, 298
 fragmentation, 591
 header coverage, 594
 IPv4, 594
 option, 712
 performance, 301
 protocol field, 712
 receiver procedure, 300
 SCTP, 740
 sender procedure, 300
 testing, 628
 UDP, 711–712
- chip, 184, 386
 choke point, 767
 chunk, 739, 743
 format, 743
 identifier, 741
 TSN, 739
- CIDR, 556
 cipher, 932
 AES, 943
 bit-oriented, 938
 Caesar, 936
 character-oriented, 938
 compression
 permutation, 940
 monoalphabetic, 935
 polyalphabetic, 935
 rotation, 939
 shift, 936
 straight permutation, 940
 substitution, 935, 939
 transposition, 937
 XOR, 938
- cipher block chaining mode.
 See CBC
 cipher feedback mode.
 See CFB
- ciphertext, 932
 RSA, 950
- CIR, 787
 circuit
 dedicated, 217
 circuit switching, 214
 acknowledgment, 217
 data transfer, 217
 delay, 217
 efficiency, 217
 telephone company, 218
- circuit-switched network, 214, 217
 telephone network, 244
- circular buffer, 717
 cladding, 198
 step-index multimode, 199
- class A address, 553
 class B address, 553

- class C address, 553
 classful addressing, 552
 blocks, 553
 classes, 553
 classless addressing, 554
 classless addressing, 555
 address allocation, 561
 classful addressing, 554
 first address, 556
 hierarchy, 561
 last address, 556
 restrictions, 555
 routing table, 656
Classless Interdomain Routing. *See* CIDR
 clear to send (CTS), 425
CLEC, 242, 1059
 POP, 243
 client, 704
 client program
 port number, 704
 client/server
 DNS, 797
 e-mail, 827
 LANE, 539
 paradigm, 704
 remote login, 817
 types, 797
 WWW, 851
 client-server paradigm, 704
Clos criteria, 230
 closed-loop congestion control, 765
coax. *See* coaxial cable
coaxial cable, 192, 195
 applications, 197
 cable TV, 197, 256
 conductor, 196
 connector, 196
 Ethernet, 198
 frequency range, 195
 HFC, 257
 performance, 197
 sheath, 196
 standards, 196
 telephone network, 197
code, 5
code division multiple access.
 See CDMA
codepoint, 585
codeword, 271, 275
 dataword, 292
 geometry, 276
coding, 101, 269
 AMI, 110
 complexity, 106
 error detection, 106
noise
 coding, 106
 NRZ, 107
 schemes, 106
 summary, 114
coding theory, 386
coherent BFSK, 147
ColdFusion, 859
collision, 364
 CSMA, 370
 CSSMA/CD, 374
 hash function, 967
 slot time, 401
 wireless, 425
collision domain, 407
Committed, 787
 committed burst size.
 See also Bc
 committed information rate.
 See also CIR
 calculation, 788
common carrier, 242
 after 1996, 1059
Common Gateway Interface.
 See CGI
community antenna TV, 256
compatible address, 571
competitive local exchange carrier. *See* CLEC
complement
 Walsh table, 389
complementary code keying.
 See CCK
composite analog signal, 74
composite signal, 66, 1046
 distortion, 83
compression
 FTP, 843
 MPEG, 907
 spatial, 907
computer data, 80
conductor
 twisted-pair, 193
 unguided media, 203
confidentiality, 962, 964, 991
configuration
 management, 874
 documentation, 874
 hardware
 reconfiguration, 874
 reconfiguration, 874
 subsystems, 874
congestion, 521, 763, 773
 additive increase, 770
 buffer, 623
 destination host, 623
 example, 763
Frame Relay, 521
ICMPv6, 639
leaky bucket, 778
multiplicative decrease, 771
prevention, 766
queue, 764
routers, 623
congestion avoidance
 Frame Relay, 773
congestion avoidance (additive increase), 772
congestion control, 522, 720,
 761, 763, 765
 closed-loop, 767
 Frame Relay, 773
 network role, 769
 open-loop, 766
 SCTP, 742, 753
congestion policy, 769
congestion window, 769
congestion window (cwnd), 730
congestion-controlled traffic, 599
connecting device, 36, 445
connection
 nonpersistent, 868
 persistent, 868
connection control, 38
connection establishment procedure, 723
 three-way handshaking, 723
connection setup, 217
connection teardown, 217
connection termination, 748
connectionless, 219
connectionless network, 219
connectionless service, 582, 707
 UDP, 713
connectionless transport layer, 38, 701
connection-oriented protocol, 538
connection-oriented service, 582, 707, 718, 738
 TCP, 45
connection-oriented transport layer, 38, 701
connector, 193
 coaxial cable, 196
 optical fiber, 200
constant bit rate traffic, 762
constellation diagram, 150
Consultative Committee for International Telegraphy and Telephony. *See* CCITT
contact address, 1061
contention, 364
contention window, 378
control chunk, 742
control field
 HDLC, 342
 types, 343
control frame, 428
control information
 SCTP, 740
control variable, 319
controlled access, 379
controller, 10, 852
convergence sublayer. *See* CS
convolution coding, 269
cookie, 725, 744–745, 853–854
 advertising agency, 854
COOKIE ACK chunk, 744
COOKIE ECHO chunk, 744
core, 198
core router, 684, 690
Core-Based Tree. *See* CBT
corrupted frame, 318
cosine wave, 1045
cosmic ray, 192
cotangent, 1046
country domain, 805
 example, 805
 mapping, 807
CPI, 534–535
CRC, 284, 535
 ATM, 532
 design, 290
 hardware
 implementation, 287
 HDLC, 342
 PPP, 348
 standard polynomial, 297
CRC-32, 399
 wireless, 427
critical angle, 198
crossbar switch, 228, 233
 limitation, 228
crosspoint, 228
crosstalk, 84, 193
cryptography, 931, 957
 comparison, 934
cryptosystem
 Diffie-Hellman, 952
CS, 532
CSMA, 370, 377
 collision, 370
 vulnerable time, 371

1116 INDEX

- CSMA/CA, 365, 377
 procedure, 378
 wireless network, 378
- CSMA/CD, 365, 373,
 377, 401
 Ethernet, 399, 401
 frame size, 374
 full-duplex switched
 Ethernet, 408
 procedure, 375
 wireless, 423, 425
- CTS, 425
- CU, 785
- curTSN, 749
- cycle, 58
 infinite, 62
 phase, 63
- cyclic code, 284
 advantages, 297
 analysis, 293
- cyclic redundancy check.
See CRC
- D**
- DA, 399
- D-AMPS, 471
- data, 4, 311
 transmission, 57
- data chunk, 742
- data communications, 4
- data compression
 presentation layer, 41
- data delivery, 747
- data element, 102, 142
- Data Encryption Standard.
See DES
- data frame, 428
 in poll, 381
- Data Link Connection
 Identifier. *See* DLCI
- data link control,
 307, 311, 363
- data link layer, 34, 307
 access control, 35
 addressing, 35
 error control, 35, 311
 flow control, 35, 311
 framing, 35, 308
 function, 34
 physical addressing, 35
 PPP, 347
 sub-layers, 363, 395
 virtual-circuit network, 227
- data link processor, 232
- Data over Cable System
 Interface Specification.
See DOCSIS
- data rate, 103
 bandwidth, 104
 maximum, 129
 signal rate, 103
- data rate limits, 85
- data traffic, 761
 descriptor, 761
- data transfer, 725, 747
 circuit switching, 217
 multi-homing, 747
 SCTP, 745
 virtual-circuit network, 223
 vs data delivery, 747
- database
 DHCP, 620
 multicasting, 681
- datagram, 45, 219, 583
 format, 583
 in IPv4, 583
 IP, 44
- datagram network, 214, 219
- dataword, 271, 275
 augmented, 288
 codeword, 292
- dc component, 105
 8B6T, 112
 bipolar, 110
 Manchester, 109
 NRZ-I and NRZ-L, 108
- DCF, 423, 442
 PIFS, 425
 repetition interval, 426
- DCT, 905
 AC value, 905
 gradient case, 905
 sharp change case, 905
 uniform gray scale
 case, 905
- DDNS, 812
 DHCP, 812
- DDS, 248
- de facto standard, 20
- de jure standard, 20
- DE PHB, 785
- decibel, 81
- decimal number, 1037
- decimal system, 1037
 symbols, 1037
 to binary, 1038
 weight and value, 1038
- decision logic analyzer, 280
- decoder, 278
- decoding
 CDMA, 387
- decryption, 932
 RSA, 950
- default mask, 553
- default method, 649
- default router, 624
- degree of polynomial, 291
- delay, 90, 764
 circuit switching, 217
 datagram network, 221
 load, 765
 real-time, 912
 time-division switch, 231
 virtual-circuit network, 226
- delayed response, 633
- delimiter, 309
- delivery, 647
 direct, 647
 end-to-end, 37, 701
 indirect, 647
 source-to-destination,
 36–37, 547, 701
 station-to-station, 36, 547
- delta modulation. *See* DM
- demodulator, 164
- demultiplexer, 162
- demultiplexing, 164, 707
 filters, 164
 transport layer, 707
- DEMUX. *See* demultiplexer
- denial of service attack, 725
- dense WDM, 168
- Department of Defense.
See DOD
- DES, 941
 triple, 943
- designated parent router, 688
- destination address. *See* DA
- destination host
 reassembly, 590
- destination option, 603
- destination service access
 point (DSAP), 396
- destination unreachable, 623
 ICMPv6, 639
- DHCP, 620
 BOOTP, 620
 configuration, 620
 database, 620
- DDNS, 812
 dynamic configuration
 protocol, 620
- dialog control, 39
- Differential Manchester, 109
- Differentiated Services.
See DF
- Diffie-Hellman, 952
- DIFS, 425
- digital
 vs analog, 57
- digital AMPS. *See* D-AMPS
- digital cellular telephone, 80
- digital data, 57, 101
- digital data service. *See* DDS
- digital service, 247
 noise, 247
- digital service unit. *See* DSU
- digital signal, 57–58,
 71, 101
 bandwidth, 74
 bit rate, 73
 composite analog signal,
 74, 79
 levels, 71
 non-periodic, 74
- digital signal service. *See* DS
- digital subscriber line.
See DSL
- digital subscriber line access
 multiplexer. *See* DSLAM
- digital to analog
 encoding, 142
- digital transmission, 101
- digital-to-analog, 141–142
 bandwidth, 143
- digital-to-digital
 conversion, 101
- Dijkstra algorithm, 668
 multicast link state
 routing, 685
- direct current, 105
- direct delivery, 647
- direct sequence spread
 spectrum. *See* DSSS
- directory services, 42
- discarding policy, 766
- Discrete Cosine Transform.
See DCT
- discrete multitone technique.
See DMT
- diskless machine, 618
- distance learning, 682
- Distance Vector Multicast
 Routing Protocol.
See DVMRP
- distance vector
 routing, 660
 initial tables, 661
- instability, 663
 RIP, 665
 sharing, 661
- distortion, 83
- distributed coordination
 function. *See* DCF
- distributed interframe space
 (DIFS), 425
- distributed processing, 7
- distribution hub, 257

- distribution system, 422
 divisor
 CRC, 286–287
 DLCI, 519
 Frame Relay, 520
 DM, 129
 adaptive, 131
 demodulator, 130
 modulator, 130
 quantization error, 131
 DMT, 252, 255
 ADSL, 253
 division of bandwidth, 252
 FDM, 252
 QAM, 252
 VDSL, 255
 voice, 252
 DNS, 797–798
 caching, 808
 country domain, 805
 divisions, 803
 domain, 802
 encapsulation, 812
 generic domain, 804
 Internet, 803
 inverted-tree
 structure, 799
 labels, 799
 levels, 799
 message, 809
 primary server, 803
 question record, 811
 record types, 811
 resolver, 806
 resource record, 811
 reverse domain, 805
 root server, 803
 secondary server, 803
 server, 802
 TCP, 812
 UDP, 812
 updating, 812
 zone, 802
 DNS message
 additional information
 section, 811
 answer section, 810
 authoritative section, 811
 header, 809
 identification field, 809
 question section, 810
 DNS response
 answer records field, 810
 question records
 field, 810
 DO command, 822
 do not fragment bit, 591
 DOCSIS, 260
 downstream, 261
 upstream, 260
 document, 854, 965
 active, 860
 dynamic, 857
 static, 855
 DOD, 17
 domain, 801
 country, 805
 generic, 805
 inverse, 805
 domain name, 799, 831
 full, 799
 Domain Name System.
 See DNS
 domains, 802
 DONT command, 822
 dotted-decimal notation, 550
 downlink, 481
 downloading
 V.90, 250
 drop cable, 256
 drop line, 11
 dropper, 786
 DS, 176, 785
 DS-0 service, 176
 DS-1 service, 176
 DS-2 service, 176
 DS-3 service, 177
 DS-4 service, 177
 field, 785
 hierarchy of digital
 signals, 176
 DS-0, 177
 DSCP, 785
 DSL, 241, 251
 limitation, 257
 DSLAM, 254
 DSSS, 184, 474–475
 bandwidth sharing, 185
 HR-DSSS, 434
 wireless, 432
 DSU, 248
 dual ring topology, 382
 dual stack, 604
 duplex, 7
 duplicate ACKs, 732
 DVMRP, 686, 690
 CBT, 690
 MBONE, 693
 PIM-DM, 692
 DWDM, 168
 dynamic, 658
 dynamic database, 620
 dynamic document, 857
 example, 857
 script, 859
 Dynamic Domain Name
 System. *See DDNS*
 Dynamic Host Configuration
 Protocol. *See DHCP*
 dynamic mapping, 612
 dynamic port, 705
 dynamic routing, 655
 dynamic routing table, 656
 dynamic table, 658
- E**
- E line, 178
 capacity, 178
 eavesdropping, 603
 ECB, 946
 echo request and reply
 messages, 625
 ICMPv6, 640
 e-commerce, 854
 EF PHB, 785
 effective bandwidth,
 104, 762
 efficiency
 circuit switching, 217
 datagram network, 220
 virtual-circuit network, 226
 EHF, 204
 EIA, 20
 interfaces, 21
 manufacturing concerns, 21
 electromagnetic energy, 192
 electromagnetic signals, 57
 electromagnetic spectrum,
 192, 203
 bands, 204
 Electronic Code Block
 (ECB), 946
 electronic code book mode.
 See ECB
 Electronic Industries
 Association. *See EIA*
 electronic mail. *See e-mail*
 electronic serial number
 (ESN), 474
 elm, 829
 e-mail, 824
 address, 831
 alias, 831
 architecture, 824
 composing, 828
 forwarding, 829
 reading, 829
 replying, 829
 encapsulation
 ARP, 615
 DNS, 812
 IGMP, 635
 Encapsulation Security
 Payload. *See ESP*
 encoder, 278
 CRC, 286
 encoding
 Ethernet, 403
 RZ, 108
 encrypted security payload.
 See ESP
 encryption, 932
 DES, 941
 IPv6, 596
 presentation layer, 40
 RSA, 950
 symmetric-key, 933
 end office, 241–242
 end switch, 243
 POP, 243
 ending tag, 534
 end-of-option option, 595
 energy level, 375
 entity, 19
 envelope, 830
 AM, 153
 ephemeral port number, 704
 queue, 714
 error, 267
 error control, 38, 307, 311,
 702, 720, 731
 concept, 311
 data link layer, 311
 HDLC, 343
 PPP, 348
 retransmission, 311
 SACK chunk, 753
 SCTP, 742, 751
 TCP, 715
 transport layer, 37, 701
 UDP, 713
 error correction, 269, 273
 block coding, 273
 minimum distance, 276
 retransmission, 269
 error detection, 269
 block coding, 116, 272
 checksum, 298
 Frame Relay, 518
 HDLC, 342
 tools, 731
 error reporting, 638
 ICMP, 622
 ICMPv6, 639
 escape character (ESC), 309
 ESP, 603, 1000
 AH protocol, 1001
 authentication data
 field, 1001

1118 INDEX

- ESP—Cont.**
- next header field, 1000
 - pad length field, 1000
 - padding field, 1000
 - procedure, 1000
 - sequence number field, 1000
 - SPI field, 1000
- ESS**, 421
- communication, 422
 - composition, 422
 - stations, 422
- ESS-transition mobility**, 423
- established**, 528
- establishment state**, 349
- Etag**, 534
- Ethernet**
- address transmission, 400
 - addressing, 400
 - BNC, 196
 - bridged, 406
 - collision, 401
 - collision domain, 407
 - CRC, 399
 - CSMA/CD, 408
 - DA, 399
 - data field, 399
 - fields, 398
 - frame length, 399
 - full-duplex switched, 408
 - implementations, 402
 - IPv6 address, 570
 - length/type field, 399
 - MAC control sublayer, 409
 - MAC frame, 398
 - MAC sublayer, 409
 - maximum frame length, 399
 - minimum data length, 399
 - multicast address, 400
 - multicasting, 636
 - network length, 402
 - preamble, 398
 - SA, 399
 - SFD, 398
 - shared capacity, 406
 - slot time, 401
 - switched, 407
 - thick, 403–405
 - thin, 404
 - unicast address, 400
- Ethernet address, 46
- Eudora, 830
- Eve, 932
- excess burst size**. *See* Be exclusive OR. *See* XOR
- exponential function, 1050
- exponential increase, 769
- exposed station, 429, 431
- extended address, 521
- Extended ASCII, 1029
- extended service set. *See* ESS
- extension header, 602
- authentication, 602
 - destination option, 603
 - ESP, 603
 - fragmentation, 602
 - hop-by-hop option, 602
 - source routing, 602
- external BGP (E-BGP), 677
- extremely high frequency. *See* EHF
- F**
- fall-back, 249
- fall-forward, 249
- Fast Ethernet, 397, 409
- autonegotiation, 409
 - backward compatibility, 409
 - encoding, 411
 - MAC sublayer, 409
 - physical layer, 410
- fast retransmission, 732
- fault identification, 10
- fault isolation
- ring, 12
- fault management, 875
- isolating the fault, 875
 - performance
 - management, 876
 - proactive, 876
 - reactive, 875
 - subsystems, 875
- FCC, 205, 477
- address, 1061
- FCS, 342
- HDLC, 342
 - PPP, 348
- FDM, 162
- applications, 167
 - carrier, 162
 - cellular telephone, 167
 - channels, 162
 - circuit-switched network, 214
- FDMA, 384
- guard bands, 163
 - implementation, 167
 - OFDM, 433
 - process, 163
 - telephone system, 165
 - TV, 167
- FDMA, 383, 470, 473, 478
- FDM, 384
- FECN, 521
- receiver, 773
- Federal Communications Committee. *See* FCC
- Feistel, 942
- DES, 941
- FHSS, 181
- bandwidth, 182
 - bandwidth sharing, 183
 - Bluetooth, 437
 - wireless, 432
- fiber, 168, 491
- fiber node, 257
- fiber-optic cable, 192
- bandwidth
 - capabilities, 491
- trunk, 242
- FIFO queueing, 776
- leaky bucket, 778
 - priority queueing, 777
- fifth harmonic, 68
- file transfer
- problems, 840
- file transfer protocol. *See* FTP
- filter
- local loop, 252
- filtering, 448
- FIN segment, 727–728
- FIN+ACK segment, 728
- final, 343
- fingerprint, 965
- firewall, 1021
- packet filter, 1022
 - proxy, 1023
- first harmonic, 68, 77
- fixed filter style, 784
- flag
- character-oriented protocol, 308
- flag field
- HDLC, 342
- flat-top sampling, 121
- flickering, 903
- flooding, 667
- multicast distance vector routing, 686
 - RPF, 686
- flow characteristics, 775
- flow class, 776
- flow control, 38, 307, 311, 701, 720
- buffer, 311
 - concept, 311
 - congestion, 623
 - data link layer, 311
 - Frame Relay, 773
 - HDLC, 343
- in IP, 623
- PPP, 348
- receiver, 311
- SCTP, 742, 748
- TCP, 715
- transport layer, 37, 701
- UDP, 713
- flow label, 597, 600
- real-time transmission, 601
 - rules for use, 601
- flow specification, 780–781
- FM, 153
- bandwidth, 154
- FM radio, 71, 167
- bandwidth, 167
- footprint, 480
- LEO, 484
- forums, 20–21
- forward error correction, 269
- forward explicit
- congestion notification. *See* FECN
- forward signal, 768
- forwarding, 647–648
- classless addressing, 650
 - forwarding techniques, 648
- four-dimensional five-level pulse amplitude modulation. *See* 4D-PAM5
- Fourier analysis, 67, 74, 1046
- Fourier series, 1046
- Fourier transform, 1048
- four-way handshake, 722, 744
- FQDN
- DNS server, 800
- FRAD, 522
- Frame Relay, 522
- fragmenation
- fragment of a fragment, 593
- fragmentation, 589, 602, 747
- checksum, 591
 - definition, 590
 - do not fragment bit, 591
 - example, 591
 - fields copied, 590
 - flags field, 591
 - fragmentation offset, 591
 - header fields, 591
 - ICMP error message, 591
 - identification field, 591
 - IPv6, 639
 - more fragment bit, 591
 - offset, 591

- reassembly, 590
reassembly steps, 593
SCTP, 747
wireless, 426
- frame, 35, 307, 342, 519, 521, 773–774
Bluetooth, 439
HDLC, 341
MPEG, 907
TDM, 170
video, 902
- frame bursting, 413
frame check sequence.
 See FCS
frame length
 Ethernet, 399
frame network, 523
 frame size, 524
- Frame Relay, 227, 517
 access rate, 787
 address field, 520
 architecture, 518
 Bc, 787
 Be, 788
 BECN, 521
 bursty data, 518
 CIR, 787
 command response
 bit, 521
 congestion, 521
 congestion avoidance, 773
 congestion situation, 774
 cost, 518
 data link layer, 520
 data rate, 518
 discard eligibility bit, 521
 DLCI, 519
 extended address bit, 521
 FECN, 521
 flow control, 773
 FRAD, 522
 frame format, 520
 frame size, 518
 layers, 518–519
 LMI, 522
 QoS, 787
 switch table, 519
 user rate, 788
 virtual circuit network, 519
 VOFR, 522
- Frame Relay assembler/
 disassembler. *See* FRAD
- frame size
 CSMA/CD, 374
- frame tag, 462
- framenetwork
 delay, 524
- framing, 307, 396
 fixed-size, 308
 MAC, 397
 variable-length, 308
- framing bit, 175
- frequency, 60, 62, 121, 142, 153
 AM, 153
 as rate of change, 62
 ASK, 143
 carrier signal, 143
 cellular telephony, 467
 extremes, 62
 FM, 154
 high, 62
 infinite, 62
 inverse, 60
 low, 62
 non-periodic signal, 74
 periodic signal, 74
 PM, 155
 PSK, 148
 sine wave, 65
 units, 61
 wavelength, 64
 zero, 62
- frequency band
 satellite
 communication, 480
- frequency division multiple access. *See* FDMA
- frequency hopping spread spectrum. *See* FHSS
- frequency masking, 904
- frequency modulation.
 See FM
- frequency shift keying.
 See FSK
- frequency-division multiplexing. *See* FDM
- frequency-domain plot, 65
- FSK, 142, 144
 frequency, 146
- FTP, 840, 852–853
 anonymous FTP, 844
 ASCII file, 842
 attributes of
 communication, 842
- binary file, 842–843
- block mode, 843
- client components, 840
- client definitions, 842
- communication, 841
- compressed mode, 843
- connections, 840
- control connection, 840–841
- data connection, 840–842
- data structure, 842
- file retrieval, 842
- file storage, 842
- file structure, 843
- file transfer, 843
- file type, 842
- HTTP, 861
- NVT, 841
- page structure, 842
- port, 1065
- ports, 840
- record structure, 842–843
- sending a directory or file
 name, 842
- server components, 840
- text file, 843
- transmission mode, 843
- full domain name, 799
- full-duplex, 7, 34
 See duplex
- full-duplex service, 718, 738
- Fully Qualified Domain Name. *See* FQDN
- fundamental frequency, 68
- G**
- G.71, 924
- G.723.1, 924
- G.723.3, 903
- G.729, 903
- gamma ray, 192
- gap
 asynchronous
 transmission, 133
- gatekeeper, 924
- gateway, 923
- gateway link (GWL), 484
- G-Back-N
 sender site, 328
- general header
 SCTP, 743
- general query message
- generator, 272, 278, 282, 953
 CRC, 285
 examples, 297
- generator polynomial, 294
- generic domain, 804
 first level, 805
 mapping, 807
- GEO satellite, 480–481
- geographical routing, 655
- geosynchronous orbit, 481
- geosynchronous satellite, 481
- GET message, 909–911
- GFSK, 437
- GIF, 857
- Gigabit Ethernet, 397, 412
 carrier extension, 413
 encoding, 415
 frame bursting, 413
 implementation, 414
 MAC sublayer, 412
 medium access, 412
 network length, 413
 physical layer, 414
 traditional, 413
- gigabit LAN
 4D-PAM5, 113
- global address, 222
- global addressing, 549
- Global Positioning System (GPS), 481
- Global System for Mobile Communication.
 See GSM
- Globalstar, 486
- Go-Back-N, 324
 acknowledgment, 327
 design, 327
 receiver site, 330
 receivewindow size, 328
 send window size, 328
 sender sliding window, 324
 sequence number, 324
 timer, 326
- Go-Back-N ARQ
 Stop-and-Wait ARQ, 331
- Go-Back-N window, 766
- Gopher, 853
 port, 1065
- government regulatory agencies, 20
- GPS, 482
- graded-index multimode optical fiber, 199
- grafting, 689
- ground propagation, 203
 antenna, 203
- group, 166
 bandwidth, 166
- group address, 679
- groupid, 632
- group-shared tree, 684
- GSM, 472, 903
- guard band, 163, 383
 jumbo group, 166
 telephone system, 166
- guard time, 384
- guest password, 844
- guided media, 192
 conductor, 192
 definition, 192
- fiber-optic cable, 192

H

H.225, 924
 H.245, 924
 H.248, 736
 H.323, 736, 920, 923
 half-close, 727–728
 half-duplex, 6, 34
 Hamming, 280
 Hamming code, 280
 performance, 283
 Hamming distance, 274
 error, 275
 minimum, 274
 handoff, 469
 handshaking
 wireless, 425
 hard handoff, 469
 hard state, 784
 harmonics, 1047
 hash algorithm, 967
 hash function, 965
 criteria, 966
 MAC, 969
 weak collision, 967
 hashing
 AH protocol, 999
 HDB3, 119
 HDLC, 340, 346
 address field, 342
 control field, 342
 definition, 340
 error detection, 342
 flag field, 342
 frame format, 342
 frame types, 341
 information field, 342
 LLC, 396
 NRM, 340
 station address, 342
 synchronization pattern, 342
 transfer modes, 340
 HDSL, 255
 2B1Q encoding, 255
 HDTV, 73
 head end, 256
 header, 32
 cell, 528
 CGI, 859
 SCTP, 740, 743
 header error, 624
 header translation, 605
 HEC, 534
 hexadecimal colon
 notation, 567
 hexadecimal system,
 1037, 1039
 to binary, 1042
 weight and value, 1039

HF, 204

HFC, 256
 bands, 258
 bandwidth, 257
 data rate, 258–259
 downstream data, 258
 downstream sharing, 259
 modulation, 258
 sharing, 259
 transmission medium, 256
 upstream data, 258
 upstream sharing, 259
 video band, 258
 hidden station, 423, 429
 hierarchical name space, 798
 hierarchical routing, 653
 hierarchy
 name server, 802
 high bit rate digital subscriber line. *See* HDSL
 high-density bipolar 3-zero.
See HDB3
 High-level Data Link Control. *See* HDLC
 high-rate DSSS.
See HR-DSSS
 HMAC, 970
 hop count, 658
 RIP, 665
 hop-by-hop option, 602
 jumbo payload, 602
 Pad1, 602
 PadN, 602
 payload, 602
 horn antenna, 206–207
 host
 routing table, 624
 host file, 798
 hostid, 553
 host-to-host delivery,
 579, 703
 host-to-host protocol, 44
 Hotmail, 839
 house voltage, 59
 HR-DSSS, 434
 HTML, 852, 855
 anchor, 857
 attribute, 856
 browser, 856
 example, 855
 graphic image, 857
 markup language, 855
 tag, 856
 HTTP, 839, 852–853, 861,
 909–911
 body, 866
 client, 861

embedded commands, 861

entity header, 866
FTP similarity, 861
general header, 864
header, 864
header categories, 864
message format, 861
MIME, 861
port, 1065
proxy server, 868
request header, 865
response header, 865
retrieval Example, 866
server, 861
SMTP similarity, 861
status code, 863
status phrase, 863
transaction, 861
version, 863
WWW, 861
hub, 10
human voice, 69
hybrid network, 1005–1006
 IP address, 1006
hybrid-fiber coaxial network.
See HFC
HyperText Markup Language.
See HTML
Hypertext Transfer Protocol.
See HTTP

I

IAB
 address, 1062
IANA, 705
ICANN, 561, 811
 address, 1062
ICMP, 43, 621
 checksum, 626
 checksum field, 622
 code field, 622
 data section, 622
 echo request and reply
 messages, 625
 error correction, 622
 error handled, 622
 error handling, 44
 error message, 622
 error reporting, 622
 error-reporting
 message, 621
 ICMP type field, 621
 IP header, 623
 loop, 624
 message format, 621
 message types, 621

ideal sampling, 121

IEEE, 20
 address, 1061
 Project 802, 395
IEEE 802.11, 421
IEEE 802.11 FHSS, 432
IEEE 802.11 infrared, 432
IEEE 802.11a OFDM, 433
IEEE 802.11b DSSS, 434
IEEE 802.15, 435
IESG
 address, 1062
IETF, 920
 address, 1062
ifconfig, 657
I-frame, 341, 343, 907
IFS, 377
IGMP, 43, 630
 address conversion, 636
 address mapping, 636
 checksum field, 632

- data-link layer, 636
 delayed response, 633–634
 destination IP address, 635
 distributing router, 632
 domain, 635
 encapsulation, 635
 Ethernet address, 636
 function, 630
 group address field, 632
 host list, 632
 host membership, 632
 ICMPv6, 596, 640
 IP protocol, 630
 joining a group, 632
 leave report, 631
 leaving a group, 633
 loyal member, 632
 maximum response type field, 631
 membership report, 631
 message format, 631
 message types, 631
 monitoring group membership, 633
 multicast routing, 685
 physical multicast addressing, 636
 protocol field, 635
 query for membership continuation, 633
 query message, 631
 query router, 635
 router membership, 632
 TTL field, 635
 tunneling, 637
 type field, 631
 WAN, 637
 ILEC, 242, 1059
 POP, 243
 image, 5
 IMAP4, 838
 IMP, 17
 impulse noise, 84
 IMT-DS, 478
 IMT-FT, 478
 IMT-MC, 478
 IMT-SC, 478
 IMT-TC, 478
 inbox, 829
 incumbent local exchange carrier. *See* ILEC
 index of refraction, 199
 indirect delivery, 647
 induced noise, 84
 infinity
 distance vector routing, 664
 RIP, 665
 information analog and digital, 57
 types, 5
 information field HDLC, 342
 Infrared Data Association (IrDA), 208
 infrared light, 192
 infrared waves, 204, 207
 applications, 208
 frequencies, 207
 infrastructure network, 421
 INIT ACK chunk, 744
 INIT chunk, 744
 initial sequence number (ISN), 721
 initiation vector (IV), 946
 inner product, 387
 input port
 packet switch, 232
 instability
 distance vector routing, 663
 instance suffix, 888
 Institute of Electrical & Electronics Engineers. *See* IEEE
 Integrated Services. *See* IntServ
 integrity, 962, 964
 AH protocol, 1000
 checking, 966
 interactive audio/video, 901
 interconnectivity, 20
 interdomain routing, 659
 path vector routing, 674
 interexchange carrier. *See* IXC
 interface
 LSP, 668
 OSI model, 31
 interface message processor. *See* IMP
 interference, 193, 267
 interframe space. *See* IFS
 Interim Standard-95. *See* IS-95
 inter-LATA service, 243
 interleaving
 cell network, 525
 frame building, 172
 synchronous TDM, 171
 TDM, 172
 internal, 235
 internal BGP (I-BGP), 677
 International Data Encryption Algorithm (IDEA), 945
 International Standards Organization. *See* ISO
 International Telecommunications Union. *See* ITU
 International Telecommunications Union–Telecommunication Standards Sector. *See* ITU-T
 Internet, 16–17, 241
 checksum, 299, 303
 current, 17
 datagram approach, 581
 datagram network, 221
 DNS, 803
 draft, 21
 history, 17
 packet-switched network, 581
 standard, 21
 internet, 15
 concept, 611
 definition, 17
 logical address, 611
 packet, 611, 658
 packet delivery, 612
 physical address, 611
 purpose, 817
 Internet Control Message Protocol. *See* ICMP
 Internet Group Management Protocol. *See* IGMP
 Internet Mail Access Protocol, version 4. *See* IMAP4
 Internet Mobile Communication, 477
 Internet phone, 912
 Internet Protocol, 579
 Internet Protocol Control Protocol. *See* IPCP
 Internet Protocol version 4. *See* IPv4
 Internet Protocol, Next Generation. *See* IPng
 Internet Protocol, Version 6. *See* IPv6
 Internet radio, 902
 Internet TV, 902
 internetwork layer. *See* network layer
 internetwork protocol. *See* IP
 internetwork. *See* internet
 internetworking protocol. *See* IP
 INTERNIC, 569
 interoperability, 19
 Interpret As Control. *See* IAC
 interpreter, 852
 inter-satellite link (ISL), 484
 intracoded frame, 907
 intradomain routing, 659
 intra-LATA service, 242
 inTransit, 749
 IntServ, 781
 DF, 785
 problems, 784
 RSVP, 782
 inverse domain, 805
 mapping, 807
 server, 805
 inverse query, 805
 INVITE message, 921
 ionosphere, 203
 IP, 17, 43–44
 advantages, 44
 analogy, 583
 congestion, 623
 connectionless protocol, 44
 datagram, 44
 deficiencies, 621
 flow control, 623
 host-to-host protocol, 44
 lack of error handling, 621
 lack of management communication, 621
 network layer protocol, 43
 protocols, 43
 routing, 44
 IP address, 45, 52, 549, 704
 ARP, 44
 binary notation, 550
 depletion, 554
 diskless machine, 618
 dotted-decimal notation, 550
 example, 47
 format, 47
 hierarchy, 559
 host, 705
 hostid, 553
 location, 618
 need for, 47
 netid, 553
 notation, 550
 RARP, 44
 unique, 549
 universal, 550

1122 INDEX

- IP addressing, 549
 IP packet, 647
 IP Security. *See* IPSec
 IP telephony, 736
 IPCP, 354
 packet format, 354
 IPng, 584
 IPSec, 996
 modes, 996
 IPv4, 549, 579, 582, 1040
 address space, 550
 address space problems, 566, 596
 analogy, 583
 audio and video problems, 596
 best-effort delivery, 583
 compared to IPv6 header, 601
 comparison to IPv6, 603
 congestion handling, 584
 connectionless, 583
 datagram, 583
 deficiencies, 596
 header translation, 605
 IPSec, 1001
 paired with TCP, 583
 reliability, 583
 security problems, 596
 transition to IPv6, 603
 tunneling, 604
 unreliable, 583
 IPv4 datagram
 checksum field, 588
 destination address field, 588
 destination protocol, 587
 differentiated services, 584
 fragmentation, 586, 590
 fragmentation offset field, 587
 header length calculation, 586
 header length field, 584
 hops allowed, 587
 identification field, 587
 loop problem, 587
 precedence subfield, 584
 priority, 584
 protocol field, 587
 reassembly, 590
 source address field, 588
 time-to-live field, 587
 TOS bits subfield, 584
 total length field, 586
 version field, 584
 IPv6, 549, 567, 596
 address abbreviation, 567
 address notation, 567
 address space, 568, 597
 compared to IPv4 header, 601
 comparison to IPv4, 603
 destination address field, 599
 destination option, 603
 ESP, 603
 extension header, 602
 extension of the protocol, 597
 flow label, 598, 600
 flow of packets, 600
 fragmentation, 602
 header format, 597
 header translation, 605
 hop limit field, 598
 IPSec, 1001
 new features, 567, 596
 new options, 597
 next header field, 598
 PadN, 602
 payload length field, 598
 priority field, 597, 599
 resource allocation, 597
 routing protocols, 597
 runs of zero, 568
 source address field, 598
 source routing, 602
 transition from IPv4, 603
 tunneling, 604
 version field, 597
 IPv6 address
 abbreviation example, 568
 consecutive zeros, 568
 fields, 569
 IPv4, 571
 multicast, 570
 provider-based, 569
 space assignment, 568
 unicast, 569
 IPv6 packet
 base header, 597
 base header fields, 597
 extension header, 597
 format, 597
 payload, 597
 IPv6 traffic, 599
 congestion-controlled, 599
 flow label, 601
 noncongestion-controlled, 600
 priority assignments, 599
 IrDA port, 208
 Iridium, 485
 IRTF
 IS-95, 474, 478
 data rate sets, 476
 reverse transmission, 475
 ISM band, 432
 DSSS, 432
 FHSS, 432
 ISO, 20, 29
 address, 1062
 purpose, 29
 ISOC
 address, 1062
 isochronous transmission, 135
 ISP, 653
 address allocation, 561
 local, 653
 national, 653
 PPP, 346
 regional, 653
 issues, 454
 iterative resolution, 808
 ITM-2000, 477
 ITU, 20
 address, 1062
 ITU-T, 20
 ATM, 523
 IUA, 736
 IXC, 1059
 POP, 244
 IXCs, 243
J
 jamming, 161
 Java, 852, 860
 Java applet, 860
 JavaScript, 852, 860
 jitter, 94, 913
 timestamp, 913
 Joint Photographic Experts Group. *See* JPEG
 JPEG, 857, 904, 908
 compression, 906
 DCT, 905
 quantization, 906
 redundancy, 904
 spatial compression, 907
 jumbo group, 166
 bandwidth, 166
 jumbo payload option, 602
K
 Kahn, Bob, 17
 KDC, 983
 AS, 984
 Kerberos, 983
 ticket, 983
 Kepler's law, 479
 Kerberos, 983–984
 operation, 984
 realm, 986
 Kevlar, 200
 key, 932, 934
 private, 934
 public, 934
 RSA, 949
 S-box, 939
 secret, 934
 keyed hash function, 969
L
 L2CAP, 440
 multiplexing, 441
 label
 country domain, 805
 generic domain, 805
 LAN, 395
 bridge, 454
 connectionless, 538
 data rate, 14
 example, 14
 Internet, 395
 interoperability, 538
 logical segments, 459
 media, 14
 multicasting, 538
 physical address, 538
 purpose, 14
 size, 14
 switched, 459
 virtual connection identifier, 538
 VLAN, 459
 wireless, 421
 LAN emulation.
 See LANE
 LANE, 538
 ATM LAN, 538
 client/server model, 539
 connectionless protocol, 538
 LEC, 539
 LECS, 539
 LES, 539
 LANE client. *See* LEC
 LANE configuration server.
 See LECS
 LANs, 454
 LATA, 242, 1059
 communication, 243
 POP, 244
 latency, 90
 components, 90
 Latin-1, 1029

- LCP, 350
 code field, 350
 PPP, 350
 leaky bucket, 777
 token bucket, 780
 lease, 620
 leave report, 631, 633
 leave report message
 destination IP address, 636
 LEC, 242, 539, 1059
 POP, 243
 LECS, 539
 legacy ATM LAN, 536
 length field, 534
 length indicator, 533, 535
 LEO satellite, 480, 484
 lexicographic ordering, 889
 LF, 204
 LI, 535
 light, 192
 line bandwidth, 248
 line coding, 101
 linear block code, 277
 cyclic code, 284
 minimum distance, 278
 line-of-sight
 microwaves, 206
 line-of-sight propagation,
 203, 481
 antenna, 203
 link, 8, 36, 162
 OSPF, 671
 point-to-point, 672
 stub, 673
 transient, 672
 virtual, 673
 link address, 46
 Link Control Protocol.
 See LCP
 link local address, 572
 link state packet. *See* LSP
 link state routing, 666
 LIST command, 842
 LLC, 363, 395–397
 framing, 396
 MAC, 396
 LMI, 522
 keepalive mechanism, 522
 multicast mechanism, 522
 status checking, 522
 load
 delay, 765
 local access transport area.
 See LATA
 local address, 571
 local area network. *See* LAN
 local call service, 247
 local central office, 242
 local exchange carrier.
 See LEC
 local Internet service provider. *See* local ISP
 local ISP, 19
 local login
 procedure, 819
 local loop, 241–242
 ADSL, 252
 bandwidth, 252
 filter, 252
 signal, 247
 switching office, 242
 Local Management Information. *See* LMI
 local part, 831
 LocalTalk address, 46
 locator, 853
 logarithmic function, 1051
 logical address, 36
 logical addressing, 549
 logical link control.
 See LLC
 logical ring, 382
 logical star backbone, 457
 login, 818
 long sequence of 0s, 108
 long-distance company, 243
 longest mask matching, 653
 loop
 multicast distance vector
 routing, 686
 RPB, 687
 time exceeded
 message, 624
 loop prevention, 675
 loopback address, 571
 loose source route, 602
 loose source route option, 596
 lossy compression, 906
 lost frame, 318
 low-Earth orbit satellite, 484
 low-pass channel, 75, 141
 band-pass, 79
 digital signal
 approximation, 76–77
 limited bandwidth, 75–76
 wide bandwidth, 75–76
 LSP, 667
 flooding, 668
 generation, 668
M
 M2UA, 736
 M3UA, 736
 MA, 365
 MAA, 827, 838
 MAC, 307, 363, 395, 969
 modules, 397
 Standard Ethernet, 398
 MAC address, 579, 704
 MAC control sublayer, 409
 MAC sublayer
 Fast Ethernet, 409
 Gigabit Ethernet, 412
 wireless LAN, 423, 442
 mail, 829
 mail access agents. *See* MAA
 mail exchanger, 831
 mail server, 825
 mailbox, 824, 831
 management frame, 427
 Management Information Base. *See* MIB
 manager, 877–878
 active open, 895
 database, 878
 function, 891
 remote reboot, 878
 Manchester
 Ethernet, 402
 Manchester coding, 109
 transition, 109
 man-in-the-middle attack, 955–956
 mapped address, 571
 mapping
 dynamic, 612
 host file, 798
 logical to physical
 address, 612
 static, 612
 marker, 786
 markup language, 855
 mask, 553
 classless addressing, 556, 559
 master group, 166
 master station, 435
 maximum burst size, 762
 maximum transfer unit.
 See MTU
 mB/nB, 115
 mBnL, 111
 MBONE, 693
 MD5, 967
 MDC, 969
 media
 guided, 192
 unguided, 203
 media access control.
 See MAC
 media gateway control, 736
 media player, 909
 medium, 4
 medium access contention, 364
 Gigabit Ethernet, 412
 random, 364
 medium-Earth orbit satellite, 481
 membership report, 631, 633
 destination IP address, 635
 MEO satellite, 480–481
 mesh, 9
 advantages, 10
 backbone, 10
 definition, 9
 disadvantages, 10
 port, 9
 mesh topology, 34
 message, 4, 965
 e-mail, 830
 message authentication code.
 See MAC
 message digest, 965, 968
 secrecy, 965
 message switching, 214
 message transfer agents.
 See MTA
 message transport part.
 See MTP
 message-oriented protocol, 736
 meta file, 909
 metric, 658, 671
 OSPF, 671
 TOS, 659
 type of service, 671
 MF, 204
 MFSK, 147
 MIB, 878, 886
 accessing simple variable, 887
 agent, 886
 example, 887
 indexes, 889
 instance definition, 888
 lexicographic ordering, 889
 object categories, 886
 object identifier tree, 887
 role, 879
 Table identification, 888
 mib object, 882
 microswitch, 234
 microwaves, 204, 206
 applications, 207
 band, 206
 frequencies, 206

- microwaves—*Cont.*
 horn antenna, 207
 IrDA port, 208
 parabolic dish
 antenna, 206
 propagation, 206
 unidirectional, 206
 unidirectional
 antenna, 206
 MID, 535
 MIME, 831
 content subtype, 833
 content-description
 header, 834
 content-Id header, 833
 content-transfer-encoding
 header, 833
 content-type
 header, 833
 headers, 832
 NVT ASCII, 831
 text data type, 833
 types of data, 833
 version header, 832
 minimum bandwidth, 104
 minimum Hamming
 distance, 274–275
 parity-check code, 278
 minislot, 261
 mixed architecture
 LAN, 537
 mixer, 916
 mixing, 916
 MLT-3, 113
 mobile station (MS), 467
 mobile switching center.
 See MSC
 mode of operation, 945
 modem, 80, 241, 248–249
 function, 248
 Shannon formula, 250
 standards, 249
 V.32, 249
 V.32bis, 261
 V.33, 261
 V.34bis, 249
 V.90, 250
 V.92, 251
 modification detection code.
 See MDC
 modular arithmetic, 270
 modulation, 143
 AM, 153
 analog-to-analog, 153
 Bluetooth, 437
 DSSS, 432
 FHSS, 432
 FM, 154
 HR-DSSS, 434
 OFDM, 434
 PM, 155
 transmission, 79
 trellis coding, 249
 modulation rate, 103
 modulator
 function, 248
 modulo 2 arithmetic, 270
 modulo 2 binary division, 286
 modulo arithmetic
 addition, 270
 subtraction, 270
 modulus, 270
 monoalphabetic
 substitution, 935
 more fragment bit, 591
 MOSPF, 685
 CBT, 690
 Motion Picture Experts
 Group. *See MPEG*
 MP3, 903
 compression, 904
 data rates, 904
 MPEG, 904, 907
 B-frame, 908
 frame types, 907
 I-frame, 907
 P-frame, 907
 temporal compression, 907
 versions, 908
 MPEG audio layer 3, 903
 MSC, 467
 handoff, 469
 receiving a signal, 469
 transmission of signal, 468
 MSS, 769
 MTA, 825, 834
 client, 834
 server, 834
 MTP, 246
 MT-RJ, 201
 MTU, 589, 639
 fragmentation, 602
 maximum length, 590
 SCTP, 752
 values for protocols, 589
 multicast address, 400
 IPv6, 570
 IPv6 permanent, 570
 IPv6 transient, 570
 multicast backbone.
 See MBONE
 multicast distance vector
 routing, 686
 DVMRP, 690
 multicast link state
 routing, 685
 Multicast Open Shortest Path
 First. *See MOSPF*
 multicast router, 632
 groupid, 632
 purpose, 633
 multicast routing, 682
 designated parent, 688
 shortest path tree, 682
 source-based tree, 683
 multicasting, 630, 678–679
 applications, 630, 681
 dissemination, 681
 distance learning, 682
 emulation, 681
 LAN, 538
 news dissemination, 681
 real-time, 915
 router interface, 679
 RSVP, 782
 teleconferencing, 682
 tunneling, 693
 UDP, 715
 unicasting, 681
 multidrop, 8
 multihomed AS, 677
 multi-homing, 738
 multilevel ASK, 145
 multilevel binary coding, 110
 multilevel coding, 111
 multilevel FSK. *See MFSK*
 multilevel multiplexing, 174
 multiline transmission, three
 level. *See MLT-3*
 multimode, 199
 optical fiber, 199
 step-index, 199
 multiple access, 363.
 See also MA
 multiple slot
 multiplexing, 174
 multiple unicasting, 680–681
 multicasting, 681
 multiple-bit error, 270, 273
 multiple-secondary
 communication, 438
 multiple-stream delivery, 737
 multiplexer, 162
 multiplexing, 161, 525, 707
 definition, 161
 L2CAP, 441
 many to one/one to
 many, 161
 transport layer, 707
 multiplexing
 identification, 535
 multiplicative decrease,
 771–772
 multiplicative inverse, 949
 multipoint, 8, 11
 multipoint configuration, 34
 Multipurpose Internet Mail
 Extensions. *See MIME*
 multistage switch, 228,
 231–233
 banyan, 233
 blocking, 229
 time-space-time
 (TST), 231
 music
 sampling rate, 902
 MUX. *See multiplexer*
- N**
- NAK
 in poll, 381
 Selective Repeat
 ARQ, 336
- name server
 hierarchy, 802
 name space, 798
 central authority, 798
 distribution, 801
 flat, 798
 hierarchical, 798
 name-address resolution, 806
 NAP, 18
 NAT, 563
 National Institute of
 Standards and
 Technology. *See NIST*
 natural base, 1050
 natural sampling, 121
 NAV, 425
 NCP, 17, 353
 netid, 553
 Netscape, 830
 network, 7, 790
 categories, 13
 criteria, 7
 definition, 17
 hybrid, 1006
 performance, 7
 private, 1006
 reliability, 8
 network access point.
 See NAP
 network address, 557
 network address translation.
 See NAT
 network capacity, 765
 Network Control Protocol.
 See NCP

- network interface card.
See NIC
- network layer, 36, 547, 579, 701, 795, 929
 at destination, 581
 at router, 581
 at source, 580
 logical Addressing, 36
 packet, 36, 547
 responsibilities, 36
 routing, 36–37, 547
 TCP/IP, 43
- network layer reliability, 708
- network length
 Gigabit Ethernet, 413
- network management, 873, 879
 accounting management, 877
 configuration, 874
 fault management, 875
 performance management, 876
 programming analogy, 880
 security management, 876
- network performance, 89, 764
- network security, 8
- network service, 582
- network support layers, 31
- network to network interfaces. *See NNI*
- network virtual terminal.
See NVT
- network-specific method, 648
- next-hop method, 648
- NIC, 400
 Ethernet, 400
 station address, 44
- NIST, 943
- NNI, 526–527
 VPI length, 527
- no operation option, 594
- node, 7, 213
- node identifier, 570
- node-to-node delivery, 703
- noise, 84
 burst error, 269
 coaxial cable, 196
 crosstalk, 84
 digital service, 247
 impulse, 84
 induced, 84
 thermal, 84
- noiseless channel, 86, 307, 312
- noisy channel, 87, 318
- non-blocking switch, 230
- non-coherent BFSK, 147
- noncongestion-controlled traffic, 600
- non-periodic composite signal, 67–68
- non-periodic signal, 58 frequency, 74
- nonpersistent connection, 868
- non-return to zero. *See NRZ*
- normal response mode.
See NRM
- normalized error, 126
- no-transition mobility, 422
- NRM, 340
- NRZ, 106–107, 144
 ASK, 144
 BFSK, 147
 BPSK, 149
- NRZ-I, 107 synchronization, 108
- NRZ-Invert, 107
- NRZ-L, 107 baseline wandering, 107 polarity switch, 108 synchronization, 108
- NRZ-Level, 107 internet, 354
- null suffix, 800
- number system
 comparison, 1040 transformation, 1041
- NVT, 41, 819
 character set, 819 control characters, 819
- FTP, 841
- TCP/IP stack, 819
- TELNET, 819 tokens, 819
- Nyquist
 bit rate, 86
- Nyquist bit rate, 86
- Nyquist formula, 104 Shannon capacity, 88
- Nyquist noiseless channel, 86
- Nyquist theorem, 121, 902 frequency, 121
- O**
- object identifier, 881
- octal system, 1037
- octet, 550
- odd number of errors, 296
- OFB, 947
- OFDM, 433
- offset, 64
- offset field, 591
- omnidirectional antenna, 205
- on-demand audio/video, 901
- one's complement arithmetic, 298
- one-slot frame, 439
- one-to-many relationship, 936
- one-to-one relationship, 935
- one-wayness, 966
- OOK, 144
- Open Shortest Path First.
See OSPF
- open system, 29
- Open Systems Interconnection.
See OSI
- open-loop congestion control, 765
- operating system
 local login, 819
 NVT, 819
- operation, 234
- optical fiber, 198
 advantages, 202
 applications, 201
 ATM, 523
 attenuation, 202
 bandwidth, 202
 cable TV, 202
 cladding, 200
 composition, 200
 connectors, 200
 core, 200
 corrosive materials, 202
 cost, 203
 density, 199
 disadvantages, 203
 electromagnetic noise, 202
 expertise, 203
 graded-index multimode, 198–199
- HFC, 257
- installation/maintenance, 203
- Kevlar, 200
- LAN, 202
- light, 198
- light weight, 203
- multimode, 198
- outer jacket, 200
- performance, 201
- propagation modes, 198
- reflection, 198
- single-mode, 198–199
- sizes, 200
- standardization, 491
- step-index multimode, 198
- tapping, 203
- unidirectional propagation, 203
- WDM, 168
- options
 end of option, 595
 function, 594
 IPv4 datagram, 594
 loose source route, 596
 no operation option, 594
 record route option, 595
 strict source route, 595
 timestamp, 596
- OPTIONS message, 921
- OR operation, 557
- orbit, 479
- orthogonal frequency-division multiplexing (OFDM), 433
- orthogonal sequence, 386, 389
- oscillator, 144
- OSI model, 29, 32, 43
 application layer, 41
 architecture, 30
 data link layer, 34
 grouping of functions, 30
 header, 32
 layer interface, 31
 layer overview, 32
 layers, 29–30, 33
 layers traversed, 30
 network layer, 36, 547
 network support layers, 31
 organization, 31
 peer-to-peer process, 30
 physical layer, 30, 33
 presentation layer, 39
 session layer, 39
 summary of layers, 42
 TCP/IP, 29, 42–43
 trailer, 32
 transport layer, 37, 701
 user support layers, 32
- OSPF, 659, 671
 link types, 671
 metric, 671
 network as a link, 671
 stub link, 673
 transient link, 672
 virtual link, 673
- outbox, 829
- Outlook, 830
- out-of-order segment, 732
- output feedback mode.
See OFB
- output port
 packet switch, 232
- outstanding frame, 325

P

packet, 658
 SCTP, 739
 packet format
 SCTP, 742
 packet payload type, 533
 packet priority, 599
 packet switch, 224
 components, 232
 output port, 233
 switching fabric, 233
 packet switching, 214
 IPv4, 583
 packet too big, 639
 packet-filter firewall, 1022
 packet-switched
 network, 214
 Pad1 option, 602
 padding, 587
 AH protocol, 999
 chunk, 743
 end of option option, 595
 Ethernet, 399
 RTP, 918
 PadN, 602
 page, 852
 paging, 469, 475
 PAM, 121
 PAP, 352
 parabolic dish antenna, 206
 parallel transmission, 131
 parameter problem
 message, 624
 ICMPv6, 639
 parity-check bit, 282
 parity-check code, 278
 parked state, 435
 Partially Qualified Domain Name. *See* PQDN
 PASS command, 844
 passive open, 723
 password, 352
 Password Authentication Protocol. *See* PAP
 path
 virtual-circuit
 network, 222
 path attribute, 677
 non-transitive, 677
 ORIGIN, 677
 transitive, 677
 path attributes
 AS_PATH, 677
 NEXT-HOP, 677
 path message, 782
 path MTU discovery technique, 602

path vector routing, 674
 loops, 675
 policy routing, 676
 sharing, 675
 P-box, 939
 PCF, 423, 425
 AP, 425
 repetition interval, 426
 PCF IFS. *See* PIFS
 PCM, 121
 bandwidth, 128
 coding, 127
 decoding, 127
 filter, 128
 sampling, 121
 PCS, 477
 PDU
 LLC, 396
 peak amplitude, 59
 peak data rate, 762
 peer-to-peer process, 30
 perceptual encoding, 903
 performance, 7
 checksum, 301
 Hamming code, 283
 performance
 management, 876
 capacity, 876
 response time, 876
 throughput, 876
 traffic, 876
 period, 58, 60, 479
 example, 60
 inverse, 60
 units, 61
 periodic analog signal, 59
 periodic composite signal, 67
 periodic signal, 58–59
 frequency, 74
 periodic update, 663
 permutation
 final DES, 941
 initial DES, 941
 permutation box.
 See P-box
 persistence method
 1-persistent, 372
 non-persistent
 approach, 372
 p-persistent, 373
 persistence methods, 372
 persistent connection, 868
 personal area network (PAN), 435
 Personal Communications System (PCS), 477

P/F bit, 343
 P-frame, 908
 Phase, 155
 phase, 142, 153
 AM, 153
 ASK, 143
 definition, 63
 example, 64
 FM, 154
 FSK, 146
 offset, 64
 PM, 155
 PSK, 148
 sine wave, 65
 phase modulation. *See* PM
 phase shift, 63
 phase shift keying.
 See PSK
 PHP, 859
 physical, 520
 physical address, 45–47,
 52, 612
 ARP, 44
 authority, 46
 need for, 612
 RARP, 44
 size and format, 46
 physical layer, 33, 55
 ATM, 529
 bit representation, 33
 bit synchronization, 34
 circuit switching, 215
 data rate, 34
 Ethernet, 397, 402
 Frame Relay, 520
 function, 33
 line configuration, 34
 OSI model, 30
 purpose, 33
 signals, 57
 tasks, 55
 TCP/IP, 43
 topology, 34
 transmission media, 191
 transmission mode, 34
 wireless, 432
 physical layer processor, 232
 physical ring topology, 382
 piconet, 435
 PIFS, 425
 piggybacking, 312, 339, 343,
 720, 722
 example, 345
 Go-Back-N ARQ, 339
 wireless transmission, 426
 pilot channel, 475
 PIM, 692

PIM-DM, 692
 PIM-SM, 692
 pipelining, 323
 pixel, 5, 71, 903, 907
 plaintext, 932
 plane, 1030
 PLAY message, 911
 playback buffer, 914
 PM, 153
 point controller, 426
 point coordination function.
 See PCF
 point of presence. *See* POP
 pointer query, 805
 point-to-point, 8, 10
 definition, 8
 mesh, 9
 point-to-point
 configuration, 34
 point-to-point
 connection, 213
 point-to-point link, 672
 Point-to-Point Protocol.
 See PPP
 poison reversed, 664
 polar coding, 107
 polar with 8-zero substitution.
 See B8ZS
 policy routing, 676
 poll, 343, 381
 polling, 380
 poll, 381
 select, 381
 polyalphabetic
 substitution, 935
 polynomial, 291
 addition, 291
 characteristics, 297
 CRC, 291
 division, 292
 multiplying, 292
 shifting, 292
 subtracting, 291
 POP, 243
 POP3, 838
 port, 705
 port address, 49
 port number, 704
 ephemeral, 704
 ICMP, 623
 process, 705
 well-known, 705, 709
 Post Office Protocol,
 version 3. *See* POP3
 POTS, 241
 power, 192
 satellite, 480

- PPM, 432
 PPP, 346
 - address field, 348
 - authentication, 352
 - authentication state, 349
 - control field, 348
 - dead state, 349
 - establishment state, 349
 - flag field, 348
 - frame, 348
 - ISP, 346
 - LCP, 350
 - multilink, 355
 - multiplexing, 350
 - networking state, 349
 - open state, 350
 - option negotiation, 351
 - payload field, 348
 - protocol field, 348
 - termination state, 350
 - transition states, 349
- PQDN
 - suffix, 800
- preamble, 398
- predicted frame, 907
- predictive encoding, 903
- presentation layer, 39
 - compression, 41
 - encryption, 40
 - responsibilities, 40
 - translation, 40
- primary
 - Bluetooth, 435
 - in polling, 381
- primary address, 747
- primary server, 803
- primary station, 340, 380
- priority field, 599
- priority queueing, 776
- privacy, 161, 962
 - AH protocol, 1000
- private address
 - NAT, 563
- private key, 933–934, 986
- private network, 1005–1006
 - IP address, 1006
- private use plane (PUP), 1032
- process-to-process communication, 709, 715
- process-to-process delivery, 703
- Project 802, 395
- propagation delay, 221
 - CSMA, 370
 - LEO, 484
- propagation speed, 402
 - distortion, 83
 - wavelength, 64
- propagation time, 90–91
 - circuit switching, 218
 - CSMA, 371
 - latency, 90
 - propagation speed, 90
- protocol, 5, 19, 30
 - definition, 19
 - elements, 19
- protocol field
 - AH protocol, 999
- Protocol Independent Multicast. *See PIM*
- Protocol Independent Multicast, Dense Mode.
 - See PIM-DM*
- Protocol Independent Multicast, Sparse Mode.
 - See PIM-SM*
- provider identifier, 570
- provider-based
 - address, 569
- proxy ARP, 617
- proxy firewall, 1023
- proxy server, 868
- pruning, 689
- pseudoheader, 712
 - purpose, 712
- pseudoterminal
 - driver, 819
- pseudoternary coding, 110
- PSK, 142, 148, 249
 - bandwidth example, 150
 - limitations, 152
 - modem, 249
 - with ASK, 152
- psychoacoustics, 903
- public key, 933–934, 986
 - Diffie-Hellman, 954
- public key infrastructure (PKI), 989
- public-key cryptography.
 - See also asymmetric-key cryptography*
 - RSA algorithm, 949
- pull program, 828
- pull protocol, 838
- pulse amplitude modulation.
 - See PAM*
- pulse code modulation.
 - See PCM*
- pulse position modulation (PPM), 432
- pulse rate, 103
- pulse stuffing, 174
- pure ALOHA, 365
 - throughput, 368
- pure ATM LAN, 536
- push operation, 726
- push program, 828
- push protocol, 837
- PVC, 528
 - ATM, 528
 - establishment, 528
- Q**
- Q.931, 924
- QAM, 142, 252
 - bandwidth, 152
 - trellis coding, 249
 - variations, 152
- QoS, 775
 - admission control, 780
 - ATM, 789
 - Bluetooth, 441
 - DF, 785
 - Frame Relay, 787
 - how to improve, 776
 - IntServ, 781
 - leaky bucket, 777
 - resource reservation, 780
 - switched network, 786
 - traffic shaping, 777
- QPSK, 149–150
 - constellation, 151
- quadrature amplitude modulation. *See QAM*
- quadrature PSK. *See QPSK*
- quality of service. *See QoS*
- quantization, 125, 906
 - non-uniform, 127
 - uniform, 127
 - zone, 125
- quantization error, 126
- quantization level, 126
- quantization noise
 - V.90, 250
- query
 - DNS, 809
- query message, 625, 631
 - destination IP address, 635
 - ICMP, 621
 - ICMP v4 and ICMPv6, 640
 - ICMPv6, 639
 - response time, 633
 - special, 633
- query router, 634–635
- question record, 811
- queue, 764
 - input, 764
 - output, 764
- overflow in UDP, 714
- UDP, 714
 - UDP client site, 714
 - UDP overflow, 715
 - UDP port, 714
 - UDP server site, 714
- queuing time, 92
- QUIT command, 844
- R**
- radio government.
 - See RG*
- radio layer, 436
- radio wave, 192, 204
 - band, 205
 - ionospheric propagation, 203
- radio waves, 192, 204
 - omnidirectional, 205
 - penetration, 205
- RAM, 231
 - TSI, 231
- random access, 364
- random access memory.
 - See RAM*
- ranging, 260
- RARP, 43
 - first boot, 44
 - ICMPv6, 596
 - logical address, 618
 - physical machine, 618
 - purpose, 44
- RARP reply, 618
- RARP request, 618
- RBOC, 1059
- RC5, 945
- RCH, 257
- realm, 986
- real-time
 - playback buffer, 914
 - threshold, 914
- real-time audio, 596
 - IPv6, 567
- real-time audio/video example, 912
- real-time data
 - time relationship, 912
- real-time interactive audio/video, 912
- Real-Time Streaming Protocol (RTSP), 911
- real-time traffic
 - error control, 916
 - mixer, 916
 - multicasting, 915
 - RTP, 916
 - sequence number, 915
 - TCP, 916

1128 INDEX

- real-time traffic—*Cont.*
 timestamp, 914
 translation, 915
 translator, 915
 UDP, 916
 real-time transmission, 4
Real-time Transport Control Protocol. *See RTCP*
Real-time Transport Protocol. *See RTP*
 receive sliding window, 324
 receiver, 4, 300
 flow control, 311
 reservation, 782
 SCTP error control, 751
 SCTP flow control, 748
 receiver window
 (rwnd), 730
 record route option, 595
 pointer-length
 comparison, 595
 recursive resolution, 808
 redirect message, 624
 purpose, 624
 redirection
 ICMPv6, 639
 redundancy, 269, 904
 checksum, 298
 spread spectrum, 181
 reflection, 198
 refraction, 198
Regional Bell Operating System. *See RBOC*
 regional cable head, 257
Regional Internet Service Providers or regional ISP. *See regional ISP*
 regional ISP, 19
 regional office, 241
 REGISTER message, 921
 registered port, 705
 registrar, 811
 registrar server, 922
Registration/Administration/ Status (RAS). 924
 regulatory agencies, 21
 REJ, 344
 relay agent, 619
 reliability, 7–8, 775
 reliable service
 SCTP, 738
 reliable transport layer
 service, 708
 remainder
 CRC, 288
 cyclic code, 294
 remote bridge, 458
 rendezvous, 684
 rendezvous router, 684, 690
 selection, 691
 repeater
 amplifier, 447
 HDSL, 255
 hub, 447
 location, 447
 ring, 12
 segment, 446
 repetition interval, 426
 Request for Comment.
 See RFC
 Request To Send (RTS), 425
 reservation, 379, 781
 refreshing, 784
 reservation frame, 379
 reserved address, 571
 resolution, 903
 iterative, 808
 name to address, 806
 recursive, 808
 resolver, 806
 resource allocation, 218
 resource record, 811
 resource reservation,
 226, 780
Resource Reservation Protocol. *See RSVP*
 resources
 circuit switching, 215
 response
 DNS, 809
 response time, 876
 Resv message, 782
 RETR command, 842
 retransmission, 732
 correction, 269
 Go-Back-N, 327
 retransmission policy, 766
 retransmission timeout
 (RTO), 732
 reuse factor, 468
 GSM, 473
 IS-95, 476
 reverse address resolution protocol. *See RARP*
 reverse path broadcasting.
 See RPB
 reverse path forwarding.
 See RPF
 reverse path multicasting.
 See RPM
 RFC, 21, 1063
 RG, 196
 coaxial cable, 196
 ratings, 196
 Rijndael algorithm, 943
 ring, 9, 12
 advantages, 12
 definition, 12
 disadvantages, 12
 dual, 12
 repeater, 12
 ring topology, 34
 RIP, 665
 port, 1065
 RIPNMC, 569
 RJ45, 193
 Rn, 326
 RNR, 344
 roaming, 469
 root, 668
 root server, 803
 rotary telephone, 244
 rotation, 939
 rotation cipher, 939
 round, 940
 AES, 944
 round cipher, 940
 AES, 943
 round key, 941
 router, 36
 address, 626
 area border, 671
 backbone, 671
 designated parent, 688
 fragmentation, 589
 input port, 232
 multicast, 632
 router advertisement
 message, 626
 router solicitation and
 advertisement message
 function, 626
 ICMPv6, 640
 router solicitation message, 626
 routing
 distance vector, 660
 example, 654
 multicast, 682
 network layer, 36–37, 547
Routing Information Protocol. *See RIP*
 routing processor, 233
 packet switch, 232
 routing protocol, 658
 multicast, 678
 routing table, 220, 224, 648,
 656, 658
 added by redirection
 flag, 657
 distance vector
 routing, 663
 dynamic, 656, 658
 flags field, 656
 gateway flag, 656
 hierarchy, 653
 host-specific flag, 657
 interface field, 656
 link state routing, 667
 mask field, 656
 modified by redirection
 flag, 657
 network address field, 656
 next hop address field, 656
 reference count field, 657
 shortest path tree, 670
 static, 656
 up flag, 656
 updating of, 624
 use field, 657
 RPB, 687
 RPF, 688
RPC
 port, 1065
 RPF, 686
 RPB, 688
RPM, 689
 graft message, 689
 prune message, 689
 RR, 343
RSA, 949
 keys, 949
 realistic example, 951
Rspec, 781
RSVP, 781–782
 IntServ, 782
 message, 782
 reservation merging, 783
 reservation style, 784
RTCP, 919
 application specific
 message, 920
 bye message, 920
 message types, 919
 port number, 920
 receiver report, 920
RTP, 919
 sender report, 919
 source description
 message, 920
RTO, 732
RTP, 916
 contributor, 918
 contributor count, 918
 extension header, 918
 header, 917
 marker, 918
 padding, 918
 payload type, 918

- port number, 919
 RTCP, 919
 sequence number, 918
 synchronization
 source, 918
 timestamp, 918
 UTP, 916
 version field, 917
 run-length encoding, 843
 rwnd, 749
 RZ, 108
 complexity, 108
 disadvantage, 108
 signal change, 108
 values, 108
- S**
- SA, 399
 SACK chunk, 753
 sample and hold, 121
 sampling, 121
 PCM, 121
 sampling frequency, 121
 sampling interval, 121
 sampling rate, 121, 902
 example, 127
 human voice, 127
 telephone company, 124
 SAR, 532
 satellite, 478
 frequency band, 481
 geosynchronous, 481
 geosynchronous, 481
 trunk, 242
 satellite communication, 478
 satellite network, 478
 satellite orbit, 479
 satellite period, 479
 sawtooth signal, 1048
 S-box, 939
 scalability, 784
 DF, 785
 scatternet, 435
 scheduling, 776
 FIFO queue, 776
 priority queue, 777
 weighted fair queueing, 777
 SCO, 439
 scrambling, 118
 script
 CGI, 859
 SCTP, 732
 acknowledgment
 number, 741
 association, 737
 chunk, 739
 data transfer, 746
- data transfer vs data delivery, 747
 features, 736
 flow control, 748
 header, 743
 packet format, 742
 reliable service, 738
 stream, 740
 verification tag, 743
 SCTP association, 743
 SCTP header, 740
 checksum field, 743
 destination port address field, 743
 source port address field, 743
 SCTP packet, 739
 vs TCP segment, 740
- SDL
 2B1Q, 111
 SDSL, 255
 SEAL, 535
 searching
 classless addressing, 655
 secondary
 Bluetooth, 435
 in polling, 381
 secondary server, 803
 secondary station,
 340, 380
 secrecy, 964–965
 secret key, 934
 secret-key cryptography.
 See symmetric-key
 cryptotgraphy
 secret-key encryption
 key, 933
 Secure Hash Algorithm.
 See SHA-1
 security, 7–8
 authentication, 962, 991
 FHSS, 183
 integrity, 962, 991
 nonrepudiation, 962, 991
 privacy, 962, 991
 security management, 876
 security parameter index.
 See SPI
- segment, 38, 406, 446, 701,
 718, 721
 format, 721
 header fields, 721
 IP datagram, 45
 size, 721
 TCP, 45
 TCP/IP, 45
- segmentation
 L2CAP, 441
 segmentation and reassembly.
 See SAR
- select
 addressing, 381
 frame, 381
 polling, 381
- Selective Repeat, 766
 Selective Repeat ARQ, 332
 design, 334
 variables, 337
 window, 333
 window size, 334
 self-synchronization, 105
 semantics, 19
 send sliding window, 324
 Sender, 300
 sender, 4, 773
 flow control, 311
 SCTP error control, 752
 SCTP flow control, 749
- sequence number, 318, 324,
 532, 535, 719, 914
 ICMP, 623
 range, 318
- sequence number field, 318
- sequence number
 protection, 532
- serial transmission, 131–132
 advantage, 132
 classes, 131
 conversion device, 132
 types, 132
- server, 704
 primary, 803
 root, 803
 secondary, 803
 UDP queue, 714
 WWW, 852
- server program, 705
 port number, 705
- service class, 781, 789
 controlled-load, 782
 guaranteed, 781
- service type. *See* TOS
- service-point address,
 38, 701
- service-point addressing, 38
- service-type limitation, 784
 DF, 785
- Session Initiation Protocol.
 See SIP
- session key, 952
 TGS, 984
- session layer, 39
 dialog control, 39
- responsibilities, 39
 synchronization, 39
 setup, 215
 virtual-circuit network,
 221, 223
- SETUP message, 911
 setup request, 224
 SFD, 398
 S-frame, 341, 343
 SHA-1, 967
 Shannon, 87
 Shannon capacity, 87
 example, 87
 noisy channel, 87
 Nyquist formula, 88
 telephone line, 87
- shaper, 786
 shared explicit style, 784
 shared-group tree
 CBT, 691
 sharing, 661
 distance vector
 routing, 661
 path vector routing, 675
- sheath, 196
 SHF, 204
 shielded twisted-pair, 193
 shift, 1044
 shift cipher, 936
 shift keying, 143
 shift register, 290
 short interframe space
 (SIFS), 425
- shortest path tree, 668
 link state routing, 667
 multicast routing, 682
 root, 668
 routing table, 670
 unicast routing, 682
- SI, 739
 SIFS, 425
- signal
 amplitude, 59
 analog and digital, 58
 aperiodic, 58
 CDMA, 388
 composite periodic
 analog, 59
 degradation, 12
 non-periodic, 58
 periodic, 58
 types, 95–96
- signal bandwidth, 248
 signal element,
 102, 142
- signal level, 86
 signal point, 245

1130 INDEX

- signal rate, 103
 2B1Q, 111
 data rate, 103
 Manchester, 110
 NRZ-I and NRZ-L, 108
 worst case, 103
- signal transport port, 245
- signaling connection control point, 246
- Signaling System Seven. *See SS7*
- signal-to-noise ratio. *See SNR*
- simple and efficient adaptation layer. *See SEAL*
- simple ciphers, 938
- Simple Mail Transfer Protocol. *See SMTP*
- Simple Network Management Protocol. *See SNMP*
- simplest protocol, 312
 algorithm, 314
 design, 313
 receiver site, 314
 sender site, 314
- simplex, 6, 34
- simultaneous open, 725
- sine wave, 59, 1043
 characteristics, 59, 65, 142
 frequency, 60
 horizontal shift, 1044
 period, 60
 vertical shift, 1045
- single-bit error, 267–268, 294
 example, 268
 frequency, 268
 two, 295
- single-mode, 199
 density, 199
 distortion, 199
 optical fiber, 199
- single-secondary communication, 437
- single-stage switch blocking, 229
- SIP, 736, 920
 addresses, 921
 messages, 921
 modules, 921
 tracking, 922
- site local address, 572
- sky propagation, 203
 ionosphere, 203
- slave station, 435
- sliding window, 324
- slot time, 401
 collision, 401
 propagation speed, 402
- slotted ALOHA, 369
 throughput, 369
 vulnerable time, 369
- slow start, 769, 868
- slow start threshold, 770
- SMI, 881
 ASN.1, 882
 BER, 884
 data type, 881
 encoding, 884
 encoding method, 881
 functions, 881
 object identifier, 881
 object name, 881
 object representation, 882
 object type, 882
 objects, 881
 role, 879
 sequence of structured type, 883
 sequence structured type, 883
 simple data type, 882
 simple type, 883
 simple type examples, 883
 structured data type, 882
 structured type, 883
 tree structure, 882
- SMTP, 834
 client commands, 835
 commands, 835
 concept, 834
 HTTP, 861
 mail transfer phases, 837
 port, 1065
 responses, 835–836
- Sn, 319, 325
- SNMP, 877, 891
 agent, 877
 agent database, 878
 BER, 893
 client program, 878
 client/server mechanism, 897
 concept, 877
 data, 893
 error index field, 893
 error status field, 893
 error types, 893
 format, 892
 function, 877
 GetBulkRequest, 892
 GetNextRequest, 891
- GetRequest, 891
 header, 893
 InformRequest, 892
 management basics, 878
 manager, 877–878
 message elements, 893
 PDU, 891
 port, 1065
 report, 892
 request ID, 892–893
 response, 892
 role, 878
 security parameters, 893
 server program, 878
 SetRequest, 892
 tag, 893
 trap, 892
 UDP PORTS, 895
 VarBindList field, 893
 version, 893
- SNMPv3, 893
 security, 897
 SNMPv2, 897
- SNR, 84
 decibel, 84
 high, 84
 in dB, 88
 low, 84
 Shannon capacity, 87
- SNRdB, 126
- socket address, 706
 IP header, 706
 pair, 706
 port number, 706
- soft handoff, 469
 IS-95, 477
- soft state, 784
- SONET, 530
 ATM, 530
 byte interleaving, 504
 video, 903
 WDM, 168
- source address. *See SA*
- source quench message, 623, 639
- source routing bridge, 453
- source routing extension header, 602
- source service access point (SSAP), 396
- source-based tree
 multicast distance vector routing, 686
- space, 231
- space-division switch, 227
 advantage, 231
 time-division, 231
- spanning tree algorithm, 452
- spatial compression, 907
- speaker node, 674
 initialization, 674
- special query message, 633
- spectrum, 154–155
- speed of light, 65
- SPI, 999
- split horizon, 664
- splitter, 254
 cable TV, 256
- splitterless ADSL, 254
- spread spectrum, 180
 bandwidth, 181
 spreading process, 181
- spreading, 161
- square wave signal, 1046
- SREJ, 344
- SS7, 218, 245
 data link layer, 246
 network layer, 246
 physical layer, 246
 transport layer, 246
 upper layers, 246
- SSN, 739
- ssthresh, 770
- ST, 535
- staircase signal, 130
- Standard Ethernet, 397
- standards, 19
 categories, 20
 creation committees, 20
 need for, 19
 ratification, 21
- standards organizations, 20
- star, 9, 11, 24
 advantages, 10
 central controller, 10
 disadvantages, 11
- star-ring topology, 382
- start bit
 asynchronous transmission, 133
- start frame delimiter. *See SFD*
- state
 multicast routing, 685
- static database, 620
- static mapping, 612
 limitations, 612
 overhead, 612
- static routing, 655
- static routing table, 655
- static table, 658
- station address, 44

- statistical TDM, 179
addressing, 179
bandwidth, 180
slot size, 180
synchronization bit, 180
step-index multimode, 199
stop bit
asynchronous
transmission, 133
stop-and-wait, 315
design, 315
receiver site, 317
sender site, 315
Stop-and-Wait ARQ, 318–319
design, 319
efficiency, 322
Go-Back-N, 331
receiver site, 321
sender site, 320
STOR command, 842
STP, 193
straight permutation, 940
straight-tip connector
(ST), 201
stream
definition, 45
SCTP, 740
stream delivery, 716
stream identifier. *See SI*
stream of bits, 55
stream sequence number.
See SSN
streaming, 909
streaming live audio/video,
901, 912
streaming server, 910
streaming stored audio/
video, 901
streaming server, 910
streaming server and
RTSP, 911
web server, 909
web server and meta
file, 909
streaming stored audio/
visual, 908
strict source route, 602
strict source route option, 595
concept, 595
rules, 596
strong collision, 967
stub AS, 676
subblock, 559
subnet
classless addressing, 559
subnet identifier field, 570
subnet masking
ICMPv6, 640
subnetting, 554, 647
Subscriber Channel
Connector (SC), 201
subscriber identifier, 570
substitution, 935
monoalphabetic, 935
substitution box.
See S-box
substitution cipher, 935
S-box, 939
suffix, 800
supergroup, 166
supernet, 554
supervisory frame.
See S-frame
supplementary ideographic
plane (SIP), 1032
supplementary multilingual
plane (SMP), 1032
supplementary special plane
(SSP), 1032
SVC, 528–529
ATM, 528–529
switch, 37, 213, 233, 408
banyan, 233
Batcher-banyan, 235
bridge, 408
crossbar, 228, 233
logical star backbone, 457
multistage, 228
non-blocking, 230
space-division, 227
structure, 227
telephone network, 242
time-division, 230
time-space-time
example, 231
two-layer, 454
switched backbone, 457
switched Ethernet, 407
switched/56, 248
subscriber, 248
switching
concept, 213
example, 213
methods, 214
need for, 213
nodes, 213
space vs time division, 231
switching fabric, 232–233
packet switch, 232
switching office, 241–242
switching table, 224
symmetric digital subscriber
line. *See SDSL*
- symmetric key
Diffie-Hellman, 952, 955
symmetric-key cryptography,
932–933
SYN flooding attack, 725
SYN segment, 724
SYN+ACK, 724
synchronization
asynchronous
transmission, 133
block coding, 115, 117
byte level, 133
clock, 105
example, 105
IS-95, 474
NRZ-I, 108
NRZ-L, 108
TDMA, 384
synchronization points, 39
synchronous connection-oriented (SCO)
link, 439
synchronous TDM, 169
data rate, 170
frame, 170
synchronous transmission,
131, 134
advantage, 135
example, 134
grouping of bits, 134
receiver function, 134
synchronization, 134
syndrome, 279
Hamming code, 282
syntax, 19
- T**
- T line, 177
digital transmission, 177
T-1 line, 177
capacity, 178
data rate, 178
frame, 177
overhead, 177
synchronization bit, 177
table
virtual-circuit
network, 223
table lookup, 233
tag
format, 856
tandem office, 241
tandem switch, 243
POP, 243
tangent, 1046
tap, 11, 256
TCB, 745
- TCP, 17, 45, 583, 703, 708
and IPv4, 583
buffer, 717, 725
checksum, 722
circular buffer, 717
connection-oriented
protocol, 723
DNS, 812
encapsulation, 723
error control, 731, 751
full-duplex, 718
full-duplex mode, 723
function, 45
ICMP, 623
OSI model, 42
ports, 1065
pseudoheader, 722
push bit, 726
push operation, 726
pushing data, 725
real-time traffic, 916
reliable service, 719
segment, 718, 721
segment re-ordering, 45
segmentation, 45, 843
sequence number, 45
SIP, 920
stream delivery, 716
stream transport
protocol, 45
streaming live audio/
video, 912
stream-oriented
protocol, 726
transport layer protocol, 43
urgent data, 726
vs SCTP, 736
well-known port
number, 709
- TCP header**
acknowledgment number
field, 721
checksum field, 722
control field, 722
destination port address
field, 721
header length field, 722
options field, 723
reserved field, 722
sequence number
field, 721
source port address
field, 721
urgent pointer field, 723
window size field, 722
- TCP segment**
vs SCTP packet, 739

- TCP/IP, 43
 addresses, 45, 52
 application layer, 42, 45
 application layer and OSI model, 45
 data link layer, 43
 file transfer, 840
 hierarchical structure, 43
 hierarchy, 43
 IP, 582
 network layer, 43
 NVT, 819
 OSI model, 29, 42–43
 physical and data link layers, 43
 physical layer, 43
 standard file transfer, 840
 transport layer, 43–44
 UDP, 45
 TCP/IP protocol suite, 42
 TDD-TDMA, 437
 TDM, 162, 169
 applications, 179
 circuit-switched network, 214
 concept, 169
 data rate, 170
 data rate management, 173
 empty slot, 173
 frame synchronization, 175
 framing bit, 175
 TDMA, 385
 time slot, 169
 TDMA, 383–384, 473, 478
 Bluetooth, 437
 TDM, 385
 teardown
 virtual-circuit network, 221
 TEARDOWN message, 912
 teardown phase, 226
 telecommunication, 3
 Telecommunications Act of 1996, 242, 1059
 teleconferencing, 682
 Teledesic, 486
 telephone company, 218
 telephone network, 241
 analog leased service, 247
 analog services, 247
 bandwidth, 247
 components, 241
 data transfer, 245
 digital service, 247
 signaling, 245
 signaling system, 244
 telephone subscriber line, 80
 telephone system
 analog switched service, 165
 hierarchy, 166
 multiplexing, 165
 telephone user port, 246
 telephony signalling, 736
 TELNET, 817–849
 character mode, 824
 client, 819
 default mode, 823
 DONT command, 822
 embedding, 820
 line mode, 824
 mode, 823
 offer to enable, 822
 option negotiation, 822
 sending control character, 821
 sending data, 820
 suboption negotiation, 822
 timesharing, 818
 user interface, 823
 WILL command, 822
 WONT command, 822
 temporal compression, 907
 temporal masking, 904
 Ten-Gigabit Ethernet, 397, 416
 terminal, 818
 terminal network. *See* TELNET
 termination
 SCTP, 748
 TFTP
 port, 1065
 TGS, 984
 AS, 984
 Kerberos, 984
 thermal noise, 84
 thick Ethernet.
 See 10BASE5
 Thicknet. *See* 10Base5
 thin Ethernet. *See* 10Base2
 third harmonic, 68
 three-node instability, 664
 three-way handshaking, 723, 727, 744
 throughput, 90, 764–765, 876
 bandwidth, 90
 CSMA/CD, 376
 load, 765
 pure ALOHA, 368
 slotted ALOHA, 369
 ticket, 983
 ticket-granting server.
 See TGS
 time division multiple access.
 See TDMA
 time exceeded message, 624
 late fragments, 624
 time-to-live field, 624
 time slot
 switching, 231
 time-division multiplexing.
 See TDM
 time-division switch, 227, 230
 pro and con, 231
 time-domain plot, 65
 time-limited signal, 1049
 time-out, 731
 timer, 326
 Selective Repeat ARQ, 339
 time-slot interchange.
 See TSI
 timestamp, 913
 ICMPv6, 640
 RTP, 918
 sender report, 919
 timestamp messages
 clock synchronization, 626
 round-trip time, 626
 timestamp option, 596
 timestamp request and reply messages, 626
 time-to-live
 caching, 809
 time-to-live field, 624
 timing, 19
 T-line
 analog transmission, 177
 bursty data, 518
 DS relationship, 177
 E-line, 178
 frame size, 177
 multiplexing, 177
 token, 381
 token bucket, 777, 779
 leaky bucket, 780
 meter, 786
 token bus, 382
 token passing, 381
 network, 382
 toll call, 243
 toll call service, 247
 toll free call, 243
 topology
 definition, 8
 TOS, 584
 categories, 585
 interpretations, 584
 values for application programs, 585
 TP, 526
 traffic, 876
 frame size, 524
 traffic control
 Frame Relay, 787
 PVC, 787
 SVC, 787
 traffic descriptor, 761
 traffic profile, 762
 traffic shaping, 777
 transceiver, 404
 transient link
 cost assignment, 673
 graphical representation, 673
 transit AS, 677
 transition
 strategies, 603
 transition phase diagram, 349
 transition strategy, 603
 header translation, 605
 tunneling, 604
 translation, 915–916
 presentation layer, 40
 translator, 915
 transmission, 57, 526
 AMPS, 470
 baseband, 75
 D-AMPS, 471
 digital signal, 74
 IS-95, 474
 modulation, 79
 serial, 131
 Transmission Control Protocol. *See* TCP
 transmission control protocol. *See* TCP
 transmission impairment, 80, 88
 transmission medium, 55
 location, 191
 physical layer, 55
 transmission mode, 131
 transmission paths. *See* TP
 transmission sequence number. *See* TSN
 transmission time, 91
 bandwidth, 91
 latency, 91
 transport layer, 37, 44, 45, 701
 connection control, 38
 demultiplexing, 707
 error control, 38, 702
 flow control, 38
 multiplexing, 707
 protocols, 44, 708

- real-time traffic, 916
 reassembly, 38
 responsibilities, 37, 44, 701
 segmentation, 38
 service-point addressing, 38, 701
 TCP, 45
 TCP/IP, 43–44
 transport mode, 996
 transposition
 DES, 941
 transposition cipher, 935, 937
 P-box, 939
 trap, 878
 trellis-coding, 249
 triangulation, 482
 triggered update, 663
 trigonometric functions, 1043
 trigonometric identities, 1046
Triple DES, 943
 2 keys, 943
 3 keys, 943
trunk, 241–242
TSI
 example, 230
 RAM, 231
TSN, 739
Tspec, 781
TST, 231
 tunneling, 604, 637
 multicasting, 693
 VPN, 1007
TV, 167
TV channel, 71
twisted-pair, 192–193
 applications, 195
 categories, 193
 components, 193
 DSL, 195
 interference, 193
 LAN, 195
 local loop, 242
 performance, 194
 RJ45, 193
 telephone network, 195
 twists, 193
twisted-pair cable, 193
twisted-pair Ethernet.
 See 10Base-T
twisting, 193
two-dimensional parity check, 280
two-node loop
 instability, 664
type of service. *See* TOS
type prefix, 568
- U**
- UA**, 824, 828
 command-driven, 829
 envelope, 830
 envelope addresses, 830
 GUI-based, 829
 mail format, 830
 mail summary, 830
 message, 830
 message body, 830
 message header, 830
 receiving mail, 830
 types, 829
- UDP**, 43, 45, 703, 707–708
 advantages, 709
 checksum, 712–713
 compared to TCP, 45
 connectionless, 709
 connectionless
 service, 713
 decapsulation, 713
 DNS, 812
 encapsulation, 713
 flow and error control, 713
 for simple communication, 715
 ICMP, 623
 incoming queue, 714
 internal control
 mechanism, 715
 management programs, 715
 multicasting and
 broadcasting, 715
 operation, 713
 outgoing queue, 714
 port creation, 714
 port unreachable, 714–715
 ports, 1065
 process-to-process
 protocol, 45
 queue overflow, 714
 queuing, 714
 real-time traffic, 916
 route-updating
 protocols, 715
 RTP, 916
 RTP port, 919
 SIP, 920
 size restriction, 713
 SNMP, 895
 transport layer protocol, 43
 unreliable, 709
 uses, 715
 vs SCTP, 736
 well-known port
 number, 709
- UDP port**
 RTCP, 920
- U-frame**, 341, 344
 codes, 344
 connection, 345
 function, 344
 system management, 341
 types, 344
- UHF**, 204
- ultraviolet light**, 192
- unguided media**, 192, 203
- UNI**, 526
 VPI length, 527
- unicast address**, 46, 400, 569
- unicast routing**, 682
 shortest path tree, 682
- unicast routing table**
 RPF, 686
- unicasting**, 630, 678
 multiple, 680
 router interface, 679
- Unicode**, 1029
 plane, 1030
- unidirectional antenna**, 206
- uniform resource locator**.
 See URL
- unipolar coding**, 106
 NRZ, 106
- UNIs**, 527
- universal ADSL**, 254
- unnumbered frame**.
 See U-frame
- unreliable transport layer**
 service, 708
- unshielded twisted pair**.
 See twisted-pair
- unspecified address**, 571
- updating**
 distance vector routing, 662
 path vector routing, 675
- uplink**, 481
- uploading**
 V.90, 250
- URG bit**, 727
- urgent byte**, 726
- URL**
 alias, 853
 anchor, 857
 components, 853
 host, 853
 HTTP, 853
 locators, 853
 pathname, 853
 port number, 853
 protocol, 853
- user**, 526
- user agent**. *See UA*
- USER command**, 843
- user datagram**, 710
 checksum example, 712
 checksum field, 711
 destination port number
 field, 711
 format, 710
 length calculation, 711
 length field, 711
 pseudoheader, 712
 source port number
 field, 710
- user datagram protocol**.
 See UDP
- user mobile link (UML)**, 484
- user network interface**.
 See UNI
- user support layers**, 32
- user-to-user ID**, 535
- UTP**, 195.
 See also twisted-pair
- UU**, 535
- UUI**, 534
- V**
- V.32**, 249
 QAM, 249
- V.32bis**, 249
- V.34bis**, 249
- V.90**, 250
 uploading, 250
- V.92**, 251
- Van Allen belt**, 481
- variable bit rate traffic**, 762
- variable-length packet**
 leaky bucket, 779
- VC**, 526
 cell network, 526
 example, 527
- VCI**, 222, 527
 length, 527
 VPC switch, 529
- VCO**, 147
- VCs**, 526
- VDSL**, 255
- verification tag**, 740
- very high bit rate digital subscriber line**.
 See VDSL
- very low frequency**. *See VLF*
- VHF**, 204
- video**, 6, 596, 902
 compression, 904
 IPv6, 567
- video conferencing**, 912
- violation**, 119

1134 INDEX

- virtual circuit
 IntServ, 781
 virtual circuit identifier.
 See VCI
 virtual circuit network
 data transfer phase, 223
 virtual circuit switching
 cknowledgment, 225
 virtual circuits. *See* VC
 virtual connection identifier (VCI), 536
 virtual link, 671
 virtual local area network.
 See VLAN
 virtual path. *See* VP
 virtual path identifier (VPI), 536
 virtual path identifier. *See* VPI
 virtual private network.
 See VPN
 virtual-circuit
 network, 214, 221
 addressing, 222
 phases, 223
 visible light, 192
 VLAN
 802.1Q, 462
 advantages, 463
 automatic
 configuration, 462
 broadcast domain, 460
 communication between switches, 462
 concept, 458
 configuration, 461
 frame tagging, 462
 grouping by IP
 address, 461
 grouping by MAC
 address, 461
 grouping by multiple characteristics, 461
 grouping by port number, 461
 logical LAN, 459
 manual configuration, 461
 membership
 characteristics, 461
 multicast IP address, 461
 semiautomatic
 configuration, 462
 table maintenance, 462
 TDM, 462
 VLF, 204
 VOFR, 522
 PCM, 522
 voice
 sampling rate, 902
 VOFR, 522
 Voice Over Frame Relay.
 See VOFR
 voice over IP, 912, 920
 voltage-controlled oscillator.
 See VCO
 volts, 59
 VP, 526
 example, 527
 VPC switch
 cell routing, 529
 example, 529
 mechanism, 529
 VPI, 527
 NNI, 527
 UNI, 527
 VPC switch, 529
 VPIs, 527, 529
 VPN, 1004, 1007
 method, 1007
 tunneling, 1007
 V-series, 249
 vulnerable time, 367
 CSMA, 371
 pure ALOHA, 368
 slotted ALOHA, 369
W
 Walsh table, 389
 WAN
 size, 14
 WATS, 247
 wave-division multiplexing.
 See WDM
 wavelength, 64
 medium, 64
 period, 64
 propagation speed, 64
 W-CDMA, 478
 WDM, 162, 167
 concept, 167
 dense, 168
 optical fiber, 168
 SONET, 168
 weak collision, 967
 Web
 functions, 853
 Web page, 852
 body, 856
 head, 856
 HTML, 855
 structure, 856
 tag, 856
 Web portal, 854
 Web site, 851
 weighted fair queueing, 777
 well-known port, 705
 list, 715, 1065
 queue, 714
 well-known port numbers
 SCTP, 736
 wide area telephone service.
 See WATS
 wide-band CDMA, 478
 wildcard filter
 style, 784
 WILL command, 822
 window
 Selective Repeat
 ARQ, 334
 window size, 769
 basis of, 769
 windowing policy, 766
 wireless, 421
 addressing mechanism, 428
 control frame, 428
 CSMA/CA, 423
 CSMA/CD, 423
 data frame, 428
 frame control field, 426
 frame format, 426
 frame types, 427
 MAC layer frame, 426
 MAC sublayer, 423
 management frame, 427
 NAV, 425
 wireless communication, 203
 wireless Ethernet, 421
 wireless LAN
 station types, 422
 wireless LAN
 station, 422
 wireless network
 CSMA/CA, 378
 World Wide Web.
 See WWW
 WWW, 851
 concept, 851
 document types, 854
 static document, 855
- X**
- X ray, 192
 X.25, 517
 X.509, 989
 xDSL, 251
 XOR, 271, 278, 286
 Hamming distance, 274
 XOR cipher, 938–939
- Y**
- Yahoo, 839
- Z**
- zone, 802
 zone file, 802