IT Passport

TECHNOLOGY

Chapter

7

Basic theory

Chapter 7 explains the fundamental concepts of radixes, sets, probabilities, and statistics, as well as the digitization of information and algorithms.

7-1 Basic theory

7-1-1 Discrete mathematics

The information managed by computers bears a close relationship with **"discrete mathematics,"** which deals with factors such as digital quantity. Discrete mathematics forms the basis of a wide number of fields, encompassing computer logic circuitry, data structures, and linguistic theory.

❶ Numbers and expression

All internal computer commands and data are expressed using binary numbers. An understanding of the fundamental logic behind the binary numbers that form the basis of data expression, as well as other types of number systems, is essential in order to perform tasks such as programming.

(1)Binary numbers, octal numbers, decimal numbers, hexadecimal numbers

A computer is capable of internally recognizing and processing data based on the transmission of electric current, voltage fluctuation, and other factors. Data recognized through such means is expressed as values featuring a combination of the symbols **"0"** and **"1."** This method is known as a **"binary number system."**

However, since it only deals with **"0"** and **"1"** arrangements, it is difficult for humans to utilize such a system. For this reason, information can also be expressed by replacing this method with a **"decimal number system,"** which consists of ten commonly used numerals (**"0"** to **"9"**). In addition, an **"octal number system"** employing numerals from **"0"** to **"7"** and a **"hexadecimal number system,"** which is comprised of the numerals **"0"** to **"9"** and alphabet letters from **"A"** to **"F"** can be utilized as well.

Binary number	Decimal number	Octal number	Hexa-decimal number	Binary number	Decimal number	Octal number	Hexa-decimal number
0	0	0	0	1001	9	11	9
1	1	1	1	1010	10	12	A
10	2	2	2	1011	11	13	B
11	3	3	3	1100	12	14	C
100	4	4	4	1101	13	15	D
101	5	5	5	1110	14	16	E
110	6	6	6	1111	15	17	F
111	7	7	7	10000	16	20	10
1000	8	10	8				

*In a hexadecimal number system, "10" through "15" are expressed using "A" to "F."

(2)Radix conversion

"Radix conversion" deals with the replacement of one number system with another.

The method of radix conversion is summarized below.

●Conversion from a binary number to a decimal number

In the same way that each digit in a decimal number system represents "10^0", "10^1", "10^2", and so on, the digits in a binary number system signify "2^0", "2^1", and "2^2", etc. Using these properties, a binary number can be converted to a decimal number.

Example Converting $(1010)_2$ to a decimal number

$$
\begin{aligned}
&(\quad 1 \qquad 0 \qquad 1 \qquad 0 \quad)_2 \\
&= 2^3\times1 + 2^2\times0 + 2^1\times1 + 2^0\times0 \\
&= 8\times1 + 4\times0 + 2\times1 + 1\times0 \\
&= 8 + 0 + 2 + 0 \\
&= (10)_{10}
\end{aligned}
$$

●Conversion from a decimal number to a binary number

By repeatedly dividing a decimal number by 2, it can be easily converted into a binary number.

Example Converting $(10)_{10}$ to a binary number

$$
\begin{array}{r|l}
2 & 10 \quad \cdots 0 \\
2 & 5 \quad \cdots 1 \\
2 & 2 \quad \cdots 0 \\
 & 1
\end{array}
$$

← Write the remainder.

← Divide by 2 until the quotient equals "1."

In the same sequence as shown by the arrow, write the final quotient and each remainder starting from the beginning of the new value, to convert the decimal number to a binary number.

$(10)_{10} \rightarrow (1010)_2$

Reference

Radix

A "radix" shows how many different numbers can be expressed within one digit.

For example, a binary number is composed using the two numbers "0" and "1," therefore its radix is "2."

Reference

Reading and writing binary numbers

If "1010" is written as is, it would not be possible to differentiate a binary number from a decimal number. To be represented as a binary number, the value must be bracketed using parentheses and denoted with a "2" after it. The resulting notation would then be "$(1010)_2$." This number can be read digit by digit as "One. Zero. One. Zero."

Reference

n^0

Regardless of which value n represents, "$n^0 = 1$" (the zero power equals "1") by definition.

Reference

Decimal Number Composition

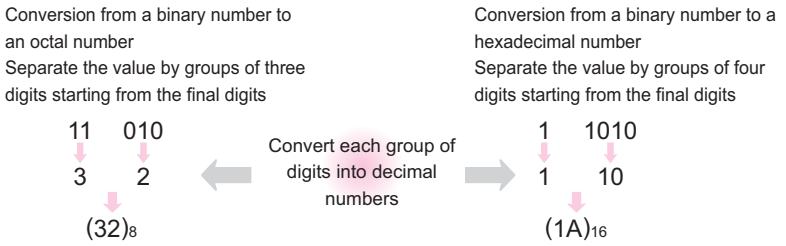
$$
\begin{aligned}
&(1 \quad 2 \quad 0 \quad 3)_{10} \\
&= 10^3\times1 + 10^2\times2 + 10^1\times0 + 10^0\times3 \\
&= 1000\times1 + 100\times2 + 10\times0 + 1\times3 \\
&= 1000 + 200 + 0 + 3 \\
&= 1203
\end{aligned}
$$

●Conversion from a binary number to an octal number or hexadecimal number

The following properties are used to convert a binary number to an octal number or hexadecimal number.

- Three binary number digits can be expressed as one octal number digit.
- Four binary number digits can be expressed as one hexadecimal number digit.

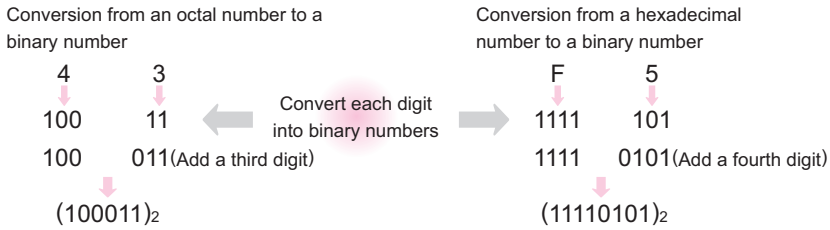
Example Converting $(11010)_2$ to an octal number and hexadecimal number



●Conversion from an octal number or hexadecimal number to a binary number

To convert an octal number or hexadecimal number to a binary number, convert each octal number digit into three binary number digits, and each hexadecimal number digit into four binary digits.

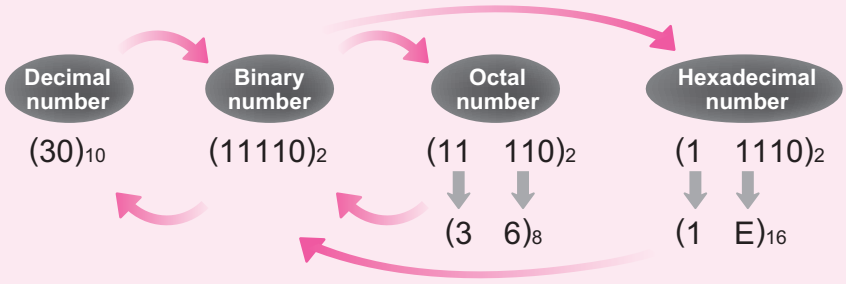
Example Converting $(43)_8$ and $(F5)_{16}$ to binary numbers



Radix conversion overview

Divide the value of the decimal number by 2 repeatedly to determine the quotients and remainders. Continue until the final quotient equals "1." Arrange the final quotient of "1" and each remainder in reverse order to convert the resulting figures to a binary number.

Separate the binary number into groups of three digits starting from the final digits. Multiply each digit by 2^0, 2^1, or 2^2, and add the resulting values to convert the figures into an octal number. Or similarly, separate the binary number into groups of four digits. Multiply each digit by 2^0, 2^1, 2^2, or 2^3, and add the resulting values to convert the figures into a hexadecimal number.



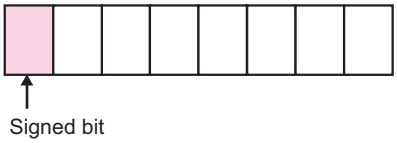
From the last digit of the binary number, multiply each successive digit by its corresponding factor (2^0, 2^1, 2^2, etc.). Add the resulting values to convert the figures into a decimal number.

Divide each digit of the octal number or hexadecimal number by 2 to determine the quotients and remainders. Continue until the final quotient equals "1." Arrange the final quotient of "1" and each remainder in reverse order. Combine the resulting values starting with those corresponding to the first digits of the original number, to convert the figures to a binary number.

* When converting to a binary number, if each digit of the original number does not equate to three or four digits, add a "0" before the resulting value until it contains the required amount (three digits for an octal number, four digits for a hexadecimal number).

(3)Signed binary numbers

A **"signed binary number system"** is a method of expression for handling binary numbers with negative values. In this method, the first bit is treated as a **"signed bit**,**"** which acts as a symbol that separates positive and negative values. If the first bit is **"0**,**"** it indicates a positive number. If the first bit is **"1**,**"** it indicates a negative number.



"0" represents a positive number. "1" signifies a negative number.

An 8-bit unsigned binary number (standard binary number) can express a value ranging from "0" to "255." A signed binary number, however, only uses seven digits to represent values since its first bit is used as a signed bit. For this reason, an 8-bit signed binary number can, at most, express a value ranging from "−128" to "127."
Two typical kinds of signed binary numbers are summarized below.

●One's complement

A **"one's complement"** reverses bits signifying a positive value in order to express a negative value.

When the value is "−3"

① Determine the bits used for positive "3"　00000011
② Reverse the bits　11111100 ····· One's complement

●Two's complement

A **"two's complement"** adds **"1"** to a one's complement to express a negative value.

When the value is "−3"

① Determine the one's complement　11111100
② Add "1" to the one's complement　+ 1

11111101 ····· Two's complement

Reference

MSB

An "MSB" is the leftmost bit of a binary number.
Abbreviation for "Most Significant Bit."

Reference

Expressible value range

The range of values which can be expressed by a particular number of bits is shown below.

Number of bits	Unsigned binary number	Signed binary number
4	0~15	−8~7
8	0~255	−128~127
12	0~4095	−2048~2047
16	0~65535	−32768~32767
32	0~4294967295	−2147483648~2147483647

Reference

Complement

A "complement" is a value that carries over one digit when it is added to another number.

(4)Addition and subtraction of binary numbers

To add or subtract binary numbers, arrange the digits in the same way as decimal numbers, and calculate from the last digits.

●Addition

During addition, digits must be carried over so that "$(1)_2 + (1)_2 = (10)_2$."

Example Calculate $(1001)_2 + (011)_2$

$$\begin{array}{rl} & \boxed{1}\boxed{1} \leftarrow \text{Digits carried over} \\ & (1001)_2 \\ + & (011)_2 \\ \hline & (1100)_2 \end{array}$$

●Subtraction

During subtraction, digits must be carried over so that "$(10)_2 - (1)_2 = (1)_2$."

Example Calculate $(1001)_2 - (011)_2$

$$\begin{array}{rl} & \boxed{0}\boxed{1} \leftarrow \text{Digits carried over} \\ & (1001)_2 \\ - & (011)_2 \\ \hline & (110)_2 \end{array}$$

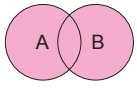
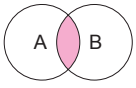
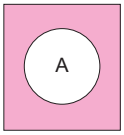
❷ Set

A **"set"** is a collection of data grouped following certain well-defined conditions.

Using sets, it is possible to express written text such as **"A OR B."** These types of statements are known as **"propositions."**

Sets expressed through propositions can be graphically represented by **"Venn diagrams."**

The relationship between three typical kinds of sets and Venn diagrams is shown below.

Set	A OR B (A + B)	A AND B (A & B)	NOT A (¬A)
Venn diagram			

In order to interpret these Venn diagrams, the **"truth-value"** is required. For the **"truth-value,"** a value of **"1"** indicates **"True,"** and a value of **"0"** indicates **"False."**

For example, if A is valid, but B is not valid, the respective truth-values would be "A = 1" and "B = 0."
If proposition **"A OR B"** is applied, this equates to **"1 OR 0,"** indicating that the proposition is logically true. However, if proposition **"A AND B"** is applied, this becomes **"1 AND 0,"** which would be logically false.
The combination of these truth-values is referred to as a **"truth table."**

	Logical sum (OR)			Logical product (AND)			Negation (NOT)	
Truth table	A	B	AORB	A	B	AANDB	A	NOT A
	1	1	1	1	1	1	0	1
	1	0	1	1	0	0	1	0
	0	1	1	0	1	0		
	0	0	0	0	0	0		

Reference

Logical Operations

A "logical operation" is a type of mathematical operation that is used when a combination featuring multiple conditions (logic) is represented by an expression.

7-1-2 Applied mathematics

The analysis of accumulated data allows for the discovery of operational problems and may provide hints that lead to the improvement of operational capabilities. During this process, **"applied mathematics"** is used. Applied mathematics is a branch of mathematics concerned with areas such as **"probability"** and **"statistics,"** which aims to impart mathematical understanding to non-mathematical fields.

1 Probability

"Probability" is a means to evaluate the total number and extent of accumulated data.

(1)permutation

A **"permutation"** is the aggregate derived when an optional count is taken from a particular collection of data, and the remaining values are arranged in an equation.
If r is arbitrarily taken from the variant n, and a sequence of the resulting numbers arranged in one row is expressed as nPr, the following expression is provided.

$$ {}_nP_r = n \times (n-1) \times (n-2) \times \cdots \times (n-r+1) $$

Example
Take four variant numbers from the values "1, 2, 3, 4, 5, 6" to derive four separate digits.

${}_6P_4 = 6 \times (6-1) \times (6-2) \times (6-3) = 6 \times 5 \times 4 \times 3 = 360$

Reference

!

"!" is a symbol that represents a factorial.
For example, "3!" is equivalent to "3 × 2 × 1."

(2)Combinations

A **"combination"** is the aggregate derived when an optional count is taken from a particular collection of data, and the respective values are removed from an equation.
If r is arbitrarily taken from the variant n, and the resulting combination of numbers is expressed as nCr, the following expression is provided.

$$ {}_nC_r = \frac{{}_nP_r}{r!} = \frac{n!}{(n-r)!\,r!} $$

Example
Take four variant numbers from the values "1", "2", "3", "4", "5", and "6."

$$ \frac{{}_6P_4}{4!} = \frac{6\times5\times4\times3}{4\times3\times2\times1} = 15 $$

(3)Probability

A **"probability"** expresses the likelihood that a certain phenomenon will occur in comparison with all applicable phenomena.
If all phenomena are expressed numerically as n, and the likelihood of phenomenon A occurring, as signified by r, in comparison to all phenomena is represented by P(A), the following expression is provided.

$$ P(A) = \frac{r}{n} $$

Example
When three out of ten lottery tickets contain a winning number, determine the probability for drawing two consecutive winning tickets.

Combination containing all phenomena:
Combination in which two out of ten tickets are drawn ··· ${}_{10}C_2 = 45$
Combination in which two consecutive winning tickets are drawn:
Combination in which two out of three winning tickets are drawn ··· ${}_3C_2 = 3$

The probability is calculated as follows.

$$ \frac{3}{45} = \frac{1}{15} $$

Example
When three out of ten lottery tickets contain a winning number, determine the probability for drawing two consecutive winning tickets. (Alternate method)

The probability of acquiring a winning ticket after drawing just once

$$\frac{\text{Number of winning tickets}}{\text{Total number of tickets}}$$

The problem is solved by considering the second draw.
Probability of acquiring a winning ticket on the first draw

$$= \frac{3}{10}$$

Probability of acquiring a winning ticket on the second draw

$$= \frac{2}{9}$$

The required probability is calculated as follows.

$$\frac{3}{10} \times \frac{2}{9} = \frac{1}{15}$$

❷ Statistics

"Statistics" are a means to examine the regularity of accumulated data, and make predictions about the future.

(1)Measure of central tendency of data

Through a **"measure of central tendency of data,"** the properties of all data can be expressed via one numeric value. Values used as a measure of central tendency of data are shown below.

Value	Explanation
Mean	The combined sum divided by the number of data sets. In general, "mean" refers to "arithmetic mean."
Median	The central value when data is arranged in either an ascending or descending order. In cases where there is an even number of data sets, the average of the two most central values is adopted.
Mode	The highest value related to the frequency of occurrence of data.

Reference

Work sampling

"Work sampling" is a means of analyzing equipment, working hours, and other details. After an observation frequency is chosen, the working status of particular employees is monitored at random intervals.

(2)Data dispersion

"Data dispersion" numerically represents the extent of spread in individual sets of data around a particular mean.

Even in cases where collections of data bear the same mean, their properties may differ as shown below.

	Data	Mean
Group A	20, 21, 22, 19, 18	$\frac{20+21+22+19+18}{5}=20$
Group B	10, 30, 5, 25, 30	$\frac{10+30+5+25+30}{5}=20$

Values that express these differences include **"variance," "standard deviation,"** and **"range,"** each of which serves as a dispersion index.

Value	Explanation
Variance	The value calculated by subtracting the mean from the value of each data set, squaring that result, adding each of those figures together, and dividing the total sum by the number of data sets.
Standard deviation	The value derived from the square root of the variance.
Range	The difference between the highest and lowest numbers contained in the data.

Although Group A and Group B have the same mean, data dispersion is calculated as follows.

	Group A	Group B
Mean	20	20
Variance	$\{(20-20)^2+(21-20)^2+(22-20)^2+(19-20)^2+(18-20)^2\}\div5$ $=(0+1+4+1+4)\div5$ $=10\div5$ $=2$	$\{(10-20)^2+(30-20)^2+(5-20)^2+(25-20)^2+(30-20)^2\}\div5$ $=(100+100+225+25+100)\div5$ $=550\div5$ $=110$
Standard deviation	$\sqrt{2}\fallingdotseq1.414$	$\sqrt{110}\fallingdotseq10.48$
Range	22−18=4	30−5=25

With the mean alone, it is not possible to accurately analyze how data is structured. Through dispersion, a strong understanding of the data's overall distribution can be gained.

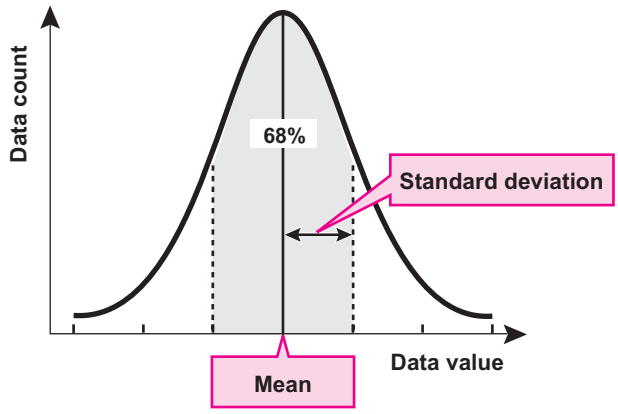
(3)Normal distribution

"Normal distribution" allows for data variation to be expressed in chart form using a convex-shaped graph known as a **"bell curve."** Rounded in the same way as an actual bell, a bell curve is symmetrically balanced to the left and right with the mean positioned at its center.

In terms of its properties, normal distribution contains data within approximately 68% of the mean plus or minus a standard deviation of 1, approximately 95% of the mean plus or minus a standard deviation of 2, and approximately 99% of the mean plus or minus a standard deviation of 3.

This data can be used to express standard kinds of knowledge such as the height of a large number of people, the weight of a large quantity of products produced by the same process, or errors in measurement.

Such properties can be utilized to predict the amount of data that differs greatly from the mean, and in turn the quantity of inferior industrial goods manufactured.



Reference

Frequency distribution table

A "frequency distribution table" is a chart that provides an overview of the state of data analysis.

Reference

Histogram

Histograms, which express dispersion through bar graphs, can also be used to represent the state of data distribution. Through histograms, information such as an overview of the data as a whole, its central position, and the magnitude of dispersion can be checked.

7-1-3 Theory of information

In order to grasp the fundamental logic behind the numeric values and data managed by computers, it is necessary to understand various concepts including methods of expressing information quantity, the reasoning behind digitization, and character representation.

1 Units measuring volume of information

"Bits" and **"bytes"** are units that are used to measure quantities of information, and represent the memory capacity and performance of a computer. Knowing about these units will also prove helpful in understanding PC performance and memory, as well as hard disk memory capacity.

Reference

Number of data types expressible by bits

1 bits 2^1 = 2 types
2 bits 2^2 = 4 types
3 bits 2^3 = 8 types
4 bits 2^4 = 16 types
5 bits 2^5 = 32 types
6 bits 2^6 = 64 types
7 bits 2^7 = 128 types
8 bits 2^8 = 256 types

Reference

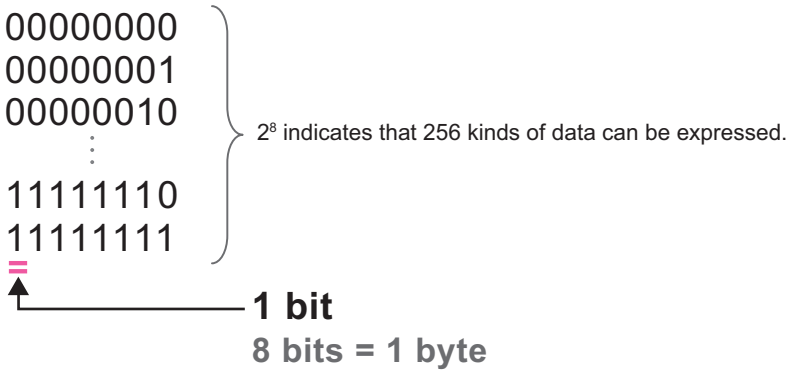
Prefixes

"Prefixes" are letters used to represent the size of bits and bytes. These include K (kilo), M (mega), and G (giga). Although not used independently, prefixes are used with other units to express the multiple of 10 applied to that particular unit.

Prefixes	Long form	Power
K	kilo	3
M	mega	6
G	giga	9
T	tera	12
P	peta	15

(1)Bits and bytes

A **"bit"** is the smallest unit of data which can be handled by a computer. In the same way as a binary number, **"one bit (also written as "1 bit" or "1 b")"** is represented by either "0" or "1." Eight bits together can be displayed as "**one byte (also written as "1 Byte" or "1 B")**."



(2)Units representing volume of information

Units used to describe information larger than a byte are summarized below.

Unit	Long form	Explanation
KB	kilobyte	2^{10} = 1024 Bytes
MB	megabyte	2^{20} = 1024 KBytes
GB	gigabyte	2^{30} = 1024 MBytes
TB	terabyte	2^{40} = 1024 GBytes
PB	petabyte	2^{50} = 1024 TBytes

*When displaying memory capacity, units are generally converted using "2^{10}" as a multiplier. Normally, a lower case "k" is written if "1000" is the multiplier, while an upper case "K" is used if "2^{10}" is the multiplier.

(3)Units representing time

To denote computer processing speed, the following units are used to represent times shorter than one second.

Unit	Long form	Explanation
ms	millisecond	$1ms=10^{-3}s=\frac{1}{10^3}s$
μs	microsecond	$1\mu s=10^{-6}s=\frac{1}{10^6}s$
ns	nanosecond	$1ns=10^{-9}s=\frac{1}{10^9}s$
ps	picosecond	$1ps=10^{-12}s=\frac{1}{10^{12}}s$

❷ Digitization

In order to manipulate **"analog data"** such as text, forms, photos, and pictures on a computer, converting it into digital code (ranging from "0" to "1") or **"digitization,"** is necessary. Through digitization, image processing, copying, communications, and other functions can be executed at high speeds, greatly expanding the application of data.

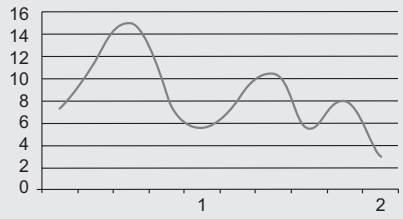
In addition, the use of digital data protects the original analog data from deterioration, allowing for more efficient data utilization.

●A/D Conversion

"A/D conversion" refers to changing analog code into digital code. Conversely, restoring digital code to analog code is referred to as **"D/A conversion."**

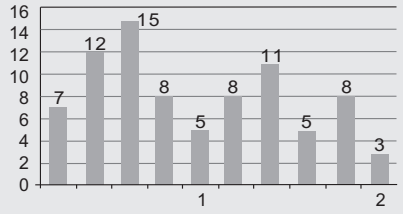
Sampling

Analog data such as music is divided and extracted at set intervals.



Quantization

The information extracted during sampling is expressed using numeric values (bits).



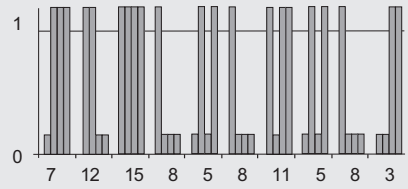
Encoding

Bits are converted to data following specific guidelines. For example, they are expressed through a radix conversion, where the data is changed from decimal numbers to binary numbers.

7	0	1	1	1
12	1	1	0	0
15	1	1	1	1
8	1	0	0	0
5	0	1	0	1
8	1	0	0	0
11	1	0	1	1
5	0	1	0	1
8	1	0	0	0
3	0	0	1	1

Coded digital display

Coded data is converted into digital data.



Reference

Encode

"Encode" refers to converting data according to specified rules. Software which performs this operation is known as an "encoder."

Reference

Decode

"Decode" refers to restoring original data by converting encoded data according to specified rules. Software which performs this operation is known as a "decoder."

Reference

Sampling rate

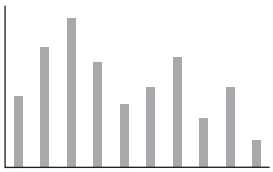
"Sampling rate" refers to the number of times analog data is measured within one second. Also referred to as "sampling frequency," this unit is expressed using "Hz." The greater the sampling rate, the better the sound quality when the digital data is replayed.

Reference

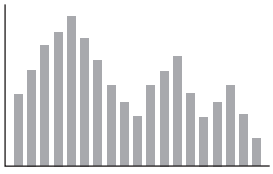
Sampling and quantization

While analog code consists of consecutively grouped data, digital code is comprised of data that is divided separately. By shortening the sampling interval and increasing the level of quantization to search for more exact values, it is possible to approach the quality of the analog data during A/D conversion.

- The longer the sampling interval, the lower the quantization level



- The shorter the sampling interval, the higher the quantization level



●Major properties of digital data

Item	Explanation
Data transmission	Transmittable to distant locations
Data sharing	Can be jointly used over a network
Data image processing	Can be editted and processed using functions such as expansion, shrinkage, and trimming
Data image quality	Does not deteriorate
Data compression	Executable
Data searching	Executable
Data copying	Executable

❸ Character representation

Internally, a computer treats characters as binary numbers. The binary code to which all characters are assigned is known as a **"character code."**

Type	Explanation
ASCII	The character code standardized by ANSI (American National Standards Institute). A 7-bit code system which expresses alphanumeric characters and symbols. By adding a parity bit, it can be represented as one byte.
JIS	The character code standardized by JIS (Japanese Industrial Standards). It consists of a 1-Byte code system, which expresses alphanumeric characters and symbols, and also a 2-Byte code system, which represents Chinese and Japanese characters.
Shift JIS	A character code standardized by Microsoft. A 2-Byte code system, which combines the JIS 2-Byte code with the ASCII 1-Byte code. It is used on a wide range of computers via Windows, Mac OS, and other operating systems.
EUC	A character code standardized by AT&T. Short for "Extended Unix Code," this 2-Byte code system allows for Chinese characters to be used via the Unix operating system.
EBCDIC	An 8-bit character code standardized by IBM in the United States. It has mostly been adopted for large, multi-purpose computers.
Unicode	A character code standardized by ISO (International Organization for Standardization) and IEC (International Electrotechnical Commission). A 2-Byte code system which incorporates characters used throughout the entire world.

Reference

Parity bit

A "parity bit" is a bit which allows for character code errors to be inspected.

Reference

EUC

Abbreviation for "Extended Unix Code."

●JIS Code Table

Last four bits / First four bits	$b_8b_7b_6b_5$	$0\,0\,0\,0$	$0\,0\,0\,1$	$0\,0\,1\,0$	$0\,0\,1\,1$	$0\,1\,0\,0$	$0\,1\,0\,1$	$0\,1\,1\,0$	$0\,1\,1\,1$	$1\,0\,0\,0$	$1\,0\,0\,1$	$1\,0\,1\,0$	$1\,0\,1\,1$	$1\,1\,0\,0$	$1\,1\,0\,1$	$1\,1\,1\,0$	$1\,1\,1\,1$
b4~b1		0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0000	0	NUL	TC7(DLE)	SP	0	@	P	`	p			Undefined	ー	タ	ミ		
0001	1	TC1(SOH)	DC1	!	1	A	Q	a	q			。	ア	チ	ム		
0010	2	TC2(STX)	DC2	"	2	B	R	b	r			「	イ	ツ	メ		
0011	3	TC3(ETX)	DC3	#	3	C	S	c	s			」	ウ	テ	モ		
0100	4	TC4(EOT)	DC4	$	4	D	T	d	t			、	エ	ト	ヤ		
0101	5	TC5(ENQ)	TC8(NAK)	%	5	E	U	e	u			・	オ	ナ	ユ		
0110	6	TC6(ACK)	TC9(SYN)	&	6	F	V	f	v			ヲ	カ	ニ	ヨ		
0111	7	BEL	TC10(ETB)	'	7	G	W	g	w			ァ	キ	ヌ	ラ		
1000	8	FE0(BS)	CAN	(	8	H	X	h	x			ィ	ク	ネ	リ		
1001	9	FE1(HT)	EM	)	9	I	Y	i	y			ゥ	ケ	ノ	ル		
1010	A	FE2(LF)	SUB	*	:	J	Z	j	z			ェ	コ	ハ	レ		
1011	B	FE3(VT)	ESC	+	;	K	[	k	{			ォ	サ	ヒ	ロ		
1100	C	FE4(FF)	IS4(FS)	,	<	L	¥	l	|			ャ	シ	フ	ワ		
1101	D	FE5(CR)	IS3(GS)	-	=	M	]	m	}			ュ	ス	ヘ	ン		
1110	E	SO	IS2(RS)	.	>	N	^	n	‾			ョ	セ	ホ	゛		
1111	F	SI	IS1(US)	/	?	O	_	o	DEL			ッ	ソ	マ	°		

Undefined

*"SP" in 0010, 0000 is the symbol for a blank space.

7-2 Algorithms and programming

7-2-1 Data structures

When developing a system, programs must be created so that the necessary functions will operate correctly. Here, the data structures and algorithms required during programming will be explained.

❶ Data and data structures

"Data" is defined as the information manipulated internally by a computer. When a collection of data is systematically organized and managed as a group, that information is known as a **"data structure."**

Data structure design serves as the entire foundation of system development. Accordingly, it is necessary to plan and investigate data structures ahead of time so that they can execute the desired tasks.

The fundamental data structures are summarized below.

Reference

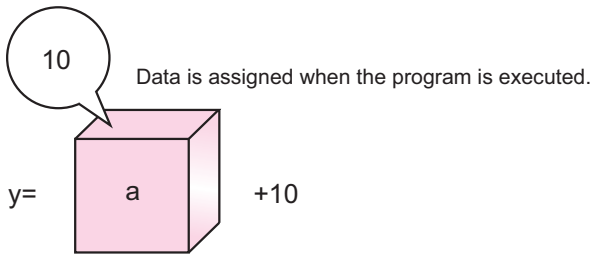
Constant

A "constant" is data possessing a certain fixed value. They are the opposite of variables.

●Variables

A **"variable"** identifies the location where data currently used by programs is stored temporarily. When defining a variable, a variable name consisting of alphanumeric characters and symbols is entered to differentiate it from other data. In addition, while it is being used, the variable is assigned a value.

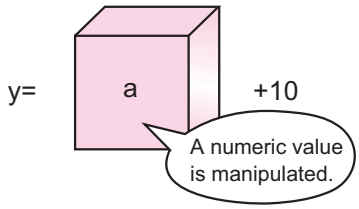
For example, in the expression **"y = a + 10,"** by assigning a value of "10" to a, y will equal "20." Since the properties of variables allow for different values to be entered each time a program is executed, there is no need to rewrite the actual program at such times.



The variable acts as a kind of box which contains the data.

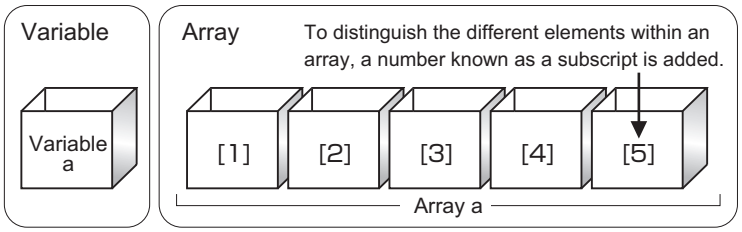
●Field types

A **"field type,"** which is also referred to as a **"data type,"** indicates different kinds of stored data. A field type, including numbers and character strings, is defined within the data which is manipulated while the program is being run. By defining the field type with a variable, it becomes possible to assign only the most suitable data, greatly improving the program's accuracy.



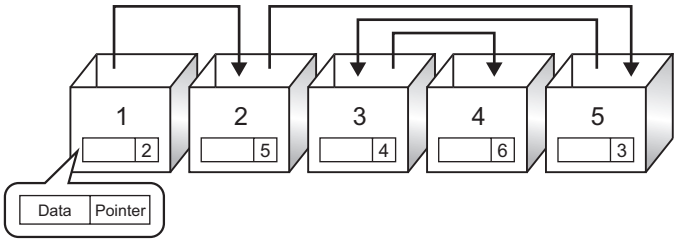
●Arrays

When a large volume of data is manipulated, it becomes useful to employ a data structure known as an **"array"** instead of a variable. In contrast to variables, which store one piece of data, arrays are capable of arranging and storing multiple pieces of the same type of data. Normally, arrays store consecutively grouped data. However, they also contain a **"subscript"** for identifying individual sets of data, making it possible to search for specific data and extract smaller pieces of data sequentially from a particular group.



●Lists

A list is a data structure which groups together multiple sets of scattered data. Similar to arrays, lists do not necessarily store only consecutively grouped data. In addition to containing the data itself, lists possess a type of information known as a **"pointer,"** which indicates the location where the next set of data is stored. When data is replaced or added, the list's order can be redefined by changing the pointers.



Reference

Precautions about arrays

Before using an array, its size and the order in which data will be assigned must be determined beforehand. If these items are changed thereafter, the array will need to be redefined.

Reference

Other data structures

- Record·· The data assigned to one row
- File ····· A collection of data

❷ Stacks and queues

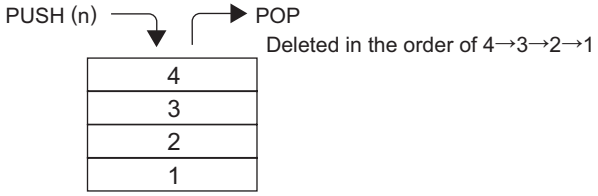
The concept of introducing and deleting data within a list is summarized below.

●Stacks

A **"stack"** is a method through which data is introduced to the end of a list, and the last data added to the list is deleted. Also referred to as a **"LIFO"** list.

The basic structure of a stack is shown below.

PUSH (n)	**Introduce the data (n)**
POP	**Delete the last piece of data**



Reference

LIFO

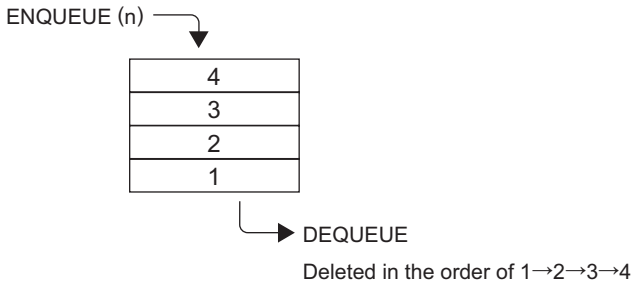
"LIFO" refers to an order in which the last data entered is the first one removed. Abbreviation for "Last-In-First-Out."

●Queues

A **"queue"** is a method through which data is introduced to the end of a list, and the first data added to the list is deleted. Also referred to as a **"FIFO"** list.

The basic structure of a queue is shown below.

ENQUEUE (n)	**Introduce the data (n)**
DEQUEUE	**Delete the first piece of data**



Reference

FIFO

"FIFO" refers to an order in which the first data entered is the first one removed.
Abbreviation for "First-In-First-Out."

7-2-2 Algorithms

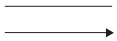
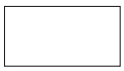
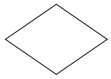
An **"algorithm"** is a processing procedure that is used to solve problems. When developing a system or conducting an operational analysis, the algorithm is considered first. Algorithms clarify which steps are taken, making it possible to create programs more efficiently.

1 Flowcharts

A **"flowchart"** is a diagram which illustrates the progression of work tasks and programming steps, utilizing various symbols and arrows.
In addition to programming steps, flowcharts can also display data paths and controls, and are used to graphically represent algorithms in an easy to understand manner.

●Flowchart symbols

The symbols which appear in flowcharts are established by Japanese Industrial Standards (JIS).
The typical symbols used are summarized below.

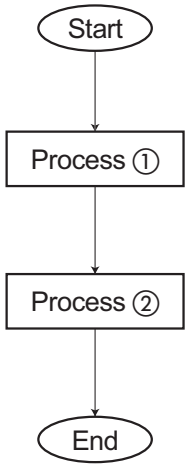
Symbol	Name	Explanation
	Terminal	Indicates the start and end of the flowchart.
	Lines	Indicates the flow of steps, data, controls, and other items.
	Process	Indicates procedures such as operations and data assignments.
	Data symbol	Indicates data input and output.
	Decision	Indicates a management function in which conditions are judged, and as a result, one process is selected out of a multiple number of choices.
	Loop limit (beginning)	Indicates the start of a loop.
	Loop limit (end)	Indicates the culmination of a loop.

❷ Basic structures of algorithms

The fundamental structures of algorithms are **"sequence structures"**, **"selection structures"**, and **"repetition structures."** Through a combination of these structures, it is possible to express complex algorithms.

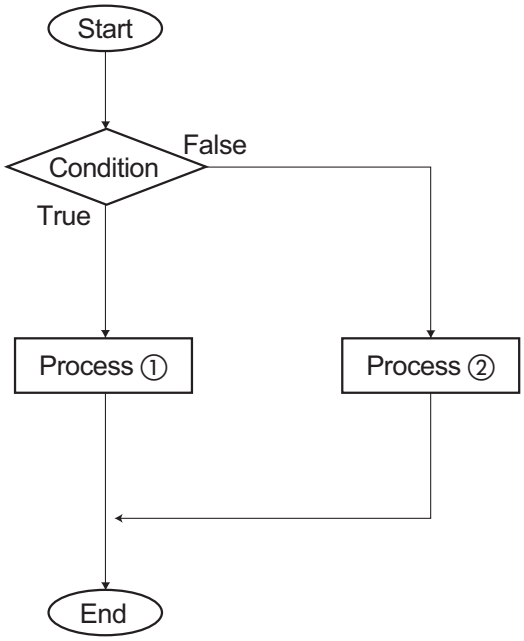
(1)Sequence structures

A **"sequence structure"** represents a flow which is carried out in a particular order.



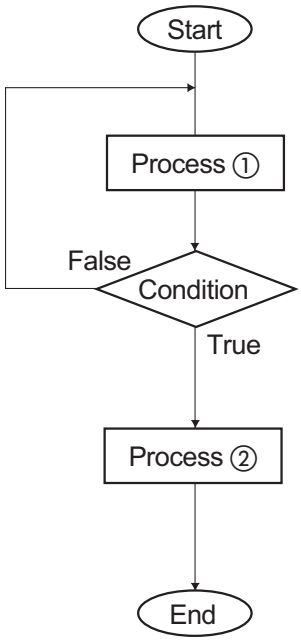
(2)Selection structures

A **"selection structure"** represents a flow through which processes are selected based on certain conditions.



(3)Repetition structures

A **"repetition structure"** represents a flow which, based on some predetermined frequency or condition, is carried out over and over again as long as some requirement is satisfied, or until some criteria has been met.



❸ Typical algorithms

The typical algorithms used are summarized below.

(1)Sum

A **"sum algorithm"** deals with addition. It is written using a sequence structure if the number of additions ranges from one to several. If that amount is always plural, however, it is written with a selection or repetition structure. Sum algorithms are the most standard type of algorithm.

Calculate "1 + 1": y = y + x

① Assign "0" to the value y (Default)
y=0+x
② Assign "1" to the value x
y=0+1
③ Assign the calculated result to the solution y
1=1
④ Assign "1" to the value x
y=1+1
⑤ Assign the calculated result to the solution y
2=2
⑥ Repeat steps ④ and ⑤ if further calculations are necessary.

Reference

Condition based repetition

When the flow repeats due to some condition, there are methods which judge the condition before the repetition occurs (pre-assessment), and also methods which judge the condition after the repetition takes place (post-assessment).

(2)Search

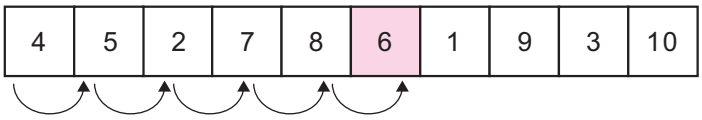
A **"search algorithm"** looks for data that matches certain conditions that are given.

These include the following types of structures.

●Linear search

A **"linear search"** is a method which checks each set of data in order, starting from the first set and ending with the last set.

Search for "6"

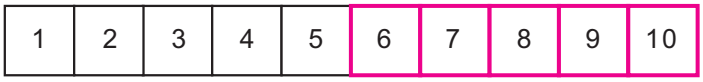


① Check whether "6" can be found in the first set of data.
② Check whether "6" can be found in the second set of data.
③ Repeat until "6" is found.

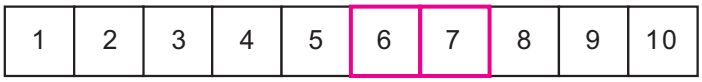
●Binary search

A **"binary search"** is a method which, starting from a central set of data, checks for information by narrowing down whether the targeted item is located before or after the central value. This method is useful when data is in ascending or descending.

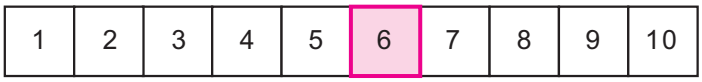
Search for "6"



① Narrow the choices down to the data located after the center.



② Within 6-10, narrow the choices down to the data located before the center.

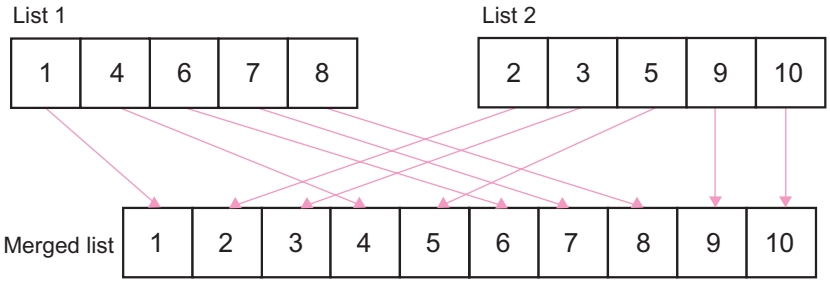


③ Within 6-7, narrow the choices down to the data located before the center.
Find "6."

(3)Merge

A **"merge algorithm"** combines two files into one while maintaining the order of data present in both files.

Combine two files into one



Data is arranged in order starting from the smallest set of data.
This repeats until the last set of data is allocated.

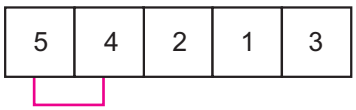
(4)Sorting

A **"sorting algorithm"** organizes the order in which data is arranged.

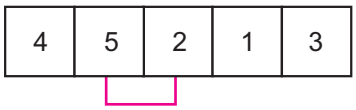
●Bubble sort

A **"bubble sort"** is a method in which the values of adjacent data are compared and then arranged in order from the first set of data to the last. This is the most standard type of sorting algorithm.

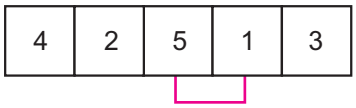
Sort data in an ascending order



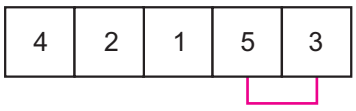
① If the first value is > the second, switch the two sets of data.



② If the second value is > the third, switch the two sets of data.



③ If the third value is > the fourth, switch the two sets of data.



④ If the fourth value is > the fifth, switch the two sets of data.

⑤ Repeat steps 1-4 until the data is arranged in order.

Reference

Sorting algorithms

There are many different kinds of sorting algorithms.

●Comparison sort

A "comparison sort" compares two sets of data and then arranges them in order. One type of comparison sort is a bubble sort.

●Insertion sort

An "insertion sort" compares two sets of data and then arranges the data by inserting it in the correct order.

●Merge sort

A "merge sort" combines data after it is sorted.

7-2-3 Programming and programming languages

A **"program"** is a collection of text that commands a computer to perform algorithms. Collectively, the rules and syntax used to describe a program are known as a **"programming language."**

❶ Types of programming languages

Different kinds of programming languages are employed depending on the objective, as well as the computer's format and usage. The act of writing algorithms while utilizing a programming language is known as **"programming."**

The typical programming languages used are summarized below.

Type		Characteristics
Low-level languages	Machine language	Language written using a binary command code that can be understood by a CPU. Machine languages differ for each type of CPU.
	Assembly Language	Language consisting of symbols representing the command sections of a machine language, which makes it easier for humans to read.
High-level languages	C	Language originally created in order to develop UNIX. It is now used by a wide range of fields through operating systems, application software, and other programs and interfaces. An updated version that supports object orientation has been developed as "C++ (C-plus-plus)."
	Java	Language which supports object orientation and is widely used by the Internet and distributed system environments. Programs created with Java operate via a runtime environment known as a "Java Virtual Machine." This allows programs to be executed by different hardware or operating systems. Java is subdivided as follows. • Java applications Programs created via Java that operate independently of browsers. • Java applets Programs created via Java that operate in conjunction with browsers. • Java servlets Programs developed via Java that execute on the server side according to browser requirements. Technical specifications of Java are as follows. • JavaBeans Technical specifications used when creating component programs (Beans) with Java. These programs can be reused and combined to develop new programs.
	COBOL	Language primarily suited for the development of programs related to administrative processes.
	FORTRAN	Language primarily suited for the development of programs related to science and technology.
	BASIC	Language frequently used by novices due to its comparatively easy-to-understand utilization of symbols. A widely used updated version known as "Visual Basic" supports the development of application software that can be run on Windows.

Reference

Low-level language

"Low-level language" is a name used for programming languages written in a format that is easy for computers to interpret.

Reference

High-level language

"High-level language" is a name used for programming languages written in a format that resembles human language and diminishes user awareness of hardware devices.

Reference

Object orientation

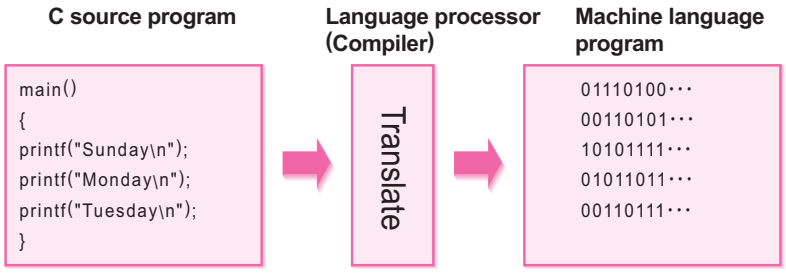
Refer to "Chapter 4-2-1 Software development processes and methods."

❷ Language processor

Programs created using high-level language cannot be executed as is by computers. In order for data to be converted (translated) into a machine language that computers understand, a software program known as a **"language processor"** is used.

The typical language processors used are summarized below.

Type	Characteristics
Compiler	It translates entire source programs into machine language with an executable format. A complete set of machine language is executed after translation, resulting in a program that runs faster than a program translated by an interpreter.
Interpreter	It executes programs while translating one command at a time from the source program into machine language. The translation and execution processes repeat for each command, resulting in a program that runs slower than a program translated by a compiler. However, it is easier to detect bugs written in the program.



7-2-4 Markup languages

A **"markup language"** is used to write logical structures in text by means of tags. A **"logical structure"** affects textual and graphical layout, character appearance (written format), and other elements. Through the use of tags, they embed control characters into text to express information related to details such as layout, character embellishment, and hyperlinks. Two typical examples of markup languages are **"HTML"** and **"XML."**

Reference

JavaScript

"JavaScript" is a script language developed by Netscape Communications. It serves as an interpreter language that is embedded in HTML, and can be executed via a browser.
It is a programming language completely separate from Java.

Reference

Cross compiler

A "cross compiler" is a language processor that translates programs using a different computer than the computer actually executing the program.

Reference

HTML

Abbreviation for "HyperText Markup Language."

Reference

SGML

"SGML" is a type of markup language that uses a text format developed to simplify data conversion for electronic publishing, text databases, and other types of applications.
Abbreviation for "Standard Generalized Markup Language."

Reference

DHTML

"DHTML," which is based on expanded HTML specifications, is a technology that enables various interactive means of expression on a Web page. It allows for more animated Web pages featuring images that display and illustrations that move in line with mouse or cursor movement.
Abbreviation for "Dynamic HTML."

1 HTML

"HTML," which was developed based on **"SGML,"** is a language used to create Web pages. It employs control characters called **"tags,"** which provide commands that direct how the page will be displayed. These tags appear as sections which are bracketed off using the symbols "<" and ">."

●Standard tags

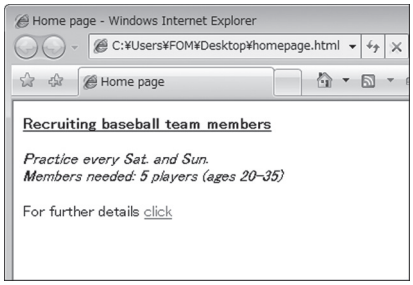
Tag	Explanation
<HTML>…</HTML>	Start and end of HTML
<HEAD>…</HEAD>	Start and end of header
<TITLE>…</TITLE>	Start and end of title
<BODY>…</BODY>	Start and end of main text
<P>…</P>	Start and end of paragraph
<B>…</B>	Start and end of boldface text
<U>…</U>	Start and end of underlined text
<I>…</I>	Start and end of italicized text
<A>…</A>	Start and end of link (indicates a link using an HREF attribute)
 	Line break

●Examples of tag notation

```
<HTML>      ← Start of HTML
 <HEAD>     ← Start of header
  <TITLE>   ← Start of title
      Home page     ←(Title)
  </TITLE>  ← End of title
 </HEAD>    ← End of header
 <BODY>     ← Start of main text
  <P><B><U>Recruiting baseball team members</U></B></P>
  <P><I>Practice every Sat. and Sun.<BR>
            Members needed: 5 players (ages 20-35)</I></P>
  <P>For further details <A HREF="http://www.fom.fujitsu.com/recruite.html">click</A></P>
 </BODY>    ← End of main text
</HTML>     ← End of HTML
```

[Main text]

Appears in browser as



❷ XML

"XML" is a markup language designed for writing data that is optimally suited for use with the Internet. Since it allows tags to be independently defined, it is said to be an expandable markup language.

XML is also capable of defining text and the information that defines text type (DTD) separately. Text written using XML is translated under the rules stipulated by the DTD, and the resulting information is displayed on-screen.

Currently, this language is widely used not only by the information services industry, but also by a wide range of companies that utilize its capabilities to disclose information or make electronic commercial transactions via the Internet.

Reference

XML

Abbreviation for "eXtensible Markup Language."

Reference

DTD

Abbreviation for "Document Type Definition."

Reference

VRML

"VRML" is a language used to manipulate three-dimensional data.
Abbreviation for "Virtual Reality Modeling Language."

7-3 Chapter quiz

*See page 11 in the "Answers and Explanations" booklet for the correct answers.

7-1

Which of the following is the binary number obtained by adding binary number 1111 and number 101?

a) 1111
b) 1212
c) 10000
d) 10100

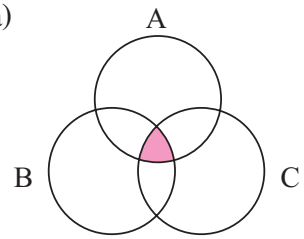
7-2

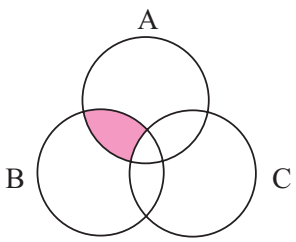
A test consisting of two questions, question 1 and question 2, was given. Among 100 examinees, 65 correctly answered question 1 and 73 correctly answered question 2. At least how many examinees correctly answered both questions?

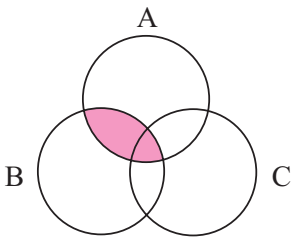
a) 35
b) 38
c) 62
d) 65

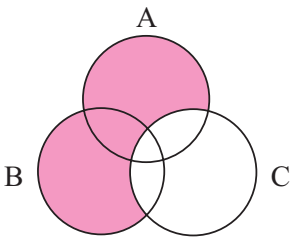
7-3

In the following Venn diagrams including three areas A, B, and C, which shaded area is "common to A and B but not C"?

a)


b)


c)


d)


7-4

At least how many bits are required to indicate the length from 0 mm to 1,000 mm in the unit of millimeters?

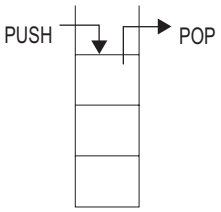
a) 4
b) 10
c) 1000
d) 1001

7-5

There is a device where articles are accumulated upwards from the bottom and taken out from upwards in sequential order. There are two kinds of operations for this device.

PUSH n: Accumulate an article (number n)
POP: Extract one article from the top

If no articles are accumulated at the beginning, which of the following is the result of the operations?



PUSH 1 → PUSH 5 → POP → PUSH 7 →
PUSH 6 → PUSH 4 → POP → POP → PUSH 3

a)


b)


c)


d)


7-6

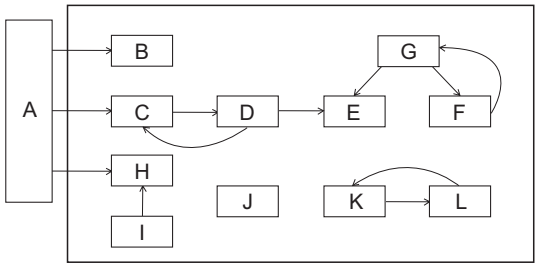
When the procedure described below is repeated to sort five numbers in ascending order, how many times is the procedure repeated until sorting is completed?

[The order of data before sorting]
5, 1, 4, 3, 2
[Procedure]
(1) If the 1st data > the 2nd data, replace the 1st and 2nd data.
(2) If the 2nd data > the 3rd data, replace the 2nd and 3rd data.
(3) If the 3rd data > the 4th data, replace the 3rd and 4th data.
(4) If the 4th data > the 5th data, replace the 4th and 5th data.
(5) When no replacement occurs, sorting is completed.
When replacement occurs, repeat the procedure from (1).

a) 1
b) 2
c) 3
d) 4

7-7

In the communication network shown below, how many nodes from B to L cannot be reached from A? Here, information can be transmitted only in the direction of arrows.



a) 1
b) 3
c) 4
d) 6

7-8

Which of the following is appropriate as the role of a programming language?

a) It enables humans to read programs automatically generated by computers.
b) It describes the number of data processed by computers.
c) It describes the procedures for computers.
d) It makes an imperfect program written by programmers into a perfect one.

7-9

Which of the following is the language used for creating a Web page on the Internet?

a) BMP
b) FTP
c) HTML
d) URL

Chapter

8

Computer system

Chapter 8 examines computer components, system components, hardware, and software, and explains each type of component and their characteristics.

8-1 Computer component

8-1-1 Processor

Reference

CPU

Abbreviation for "Central Processing Unit."

The **"processor"** or **"CPU (Central Processing Unit),"** is a critical device that can be considered the brains and nucleus of a computer.
A computer is comprised of devices that perform various functions centering on the CPU. When using a computer, it is important to understand the basic components of a computer and how they work.

❶ Computer configuration

A computer is configured from devices that possess the five functions of **"input"**, **"output"**, **"control"**, **"operation"**, and **"storage."** The roles performed by the five major types of devices are summarized below.

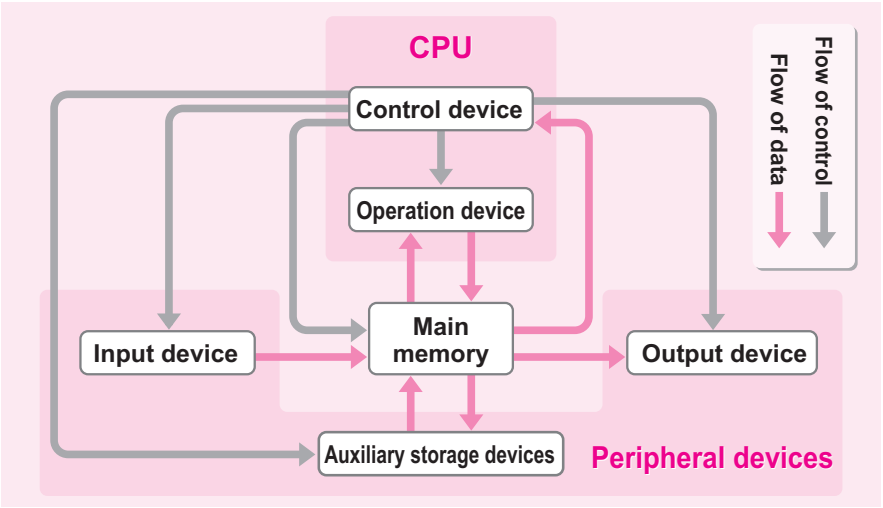
Device	Task
Control device	Interprets programs and sends instructions to other devices.
Operation device	Performs calculations according to the instructions within programs. Combined with the control device, it is referred to as the CPU.
Storage device	Stores programs and data. Divided into "main memory" and "auxiliary storage devices."
Input device	Inputs data to the main memory.
Output device	Outputs data from the main memory (display, print, etc.).

The flow of data and control between the respective devices is shown below.

Reference

Peripheral device

A "peripheral device" is a device other than the CPU and main memory.



For example, a program that processes the equation **"1 + 2 ="** inputted from a keyboard, operates according to the following sequence.

① **"1 + 2 ="** is inputted using the input device (keyboard)
② **"1 + 2 ="** is stored in the storage device (main memory)
③ **"1 + 2 ="** is calculated by the operation device (CPU)
④ The result **"3"** is stored in the storage device (main memory)
⑤ **"3"** is displayed by the output device (display)

❷ Basic framework of CPUs

The CPUs of earlier computers were comprised of multiple chips, but advancements in technology have enabled the CPU to be contained on a single chip. A CPU that is comprised of a single chip is called a **"microprocessor."**
The basic framework and functions of a CPU are summarized below.

(1)CPU

The CPU incorporates **"control"** functions that send instructions to the various devices, and **"operation"** functions that perform calculations according to instructions contained within programs.
Due to increasing miniaturization, some CPUs are now small enough to fit on a fingertip.

●CPU throughput

The processing speed of a computer is heavily influenced by the performance of the CPU. A CPU is categorized by the number of bits it can process at one time. A **"16-bit CPU"** and **"32-bit CPU"** can process 16 and 32 bits at a time respectively. Higher bits indicate greater throughput and a higher performance CPU.

Reference

MPU

An "MPU" is a device which contains CPU functions on a single "large-scale integrated (LSI)" circuit. For computers, a CPU is sometimes called an "MPU." Abbreviation for "Micro Processing Unit."

Reference

Chip

A "chip" is a component that makes up an electronic part such as a CPU. Chips are small in size and measure just a few millimeters on each side. Electronic circuits are embedded into the chip.

Reference

x86

The "x86" processors are a series of CPUs developed by Intel. The 8086 processor was followed in succession by the release of the 8088, 80186, 80286, i386, and i486 processors.

●Types of CPUs

Several types of CPUs are summarized below.

Brand	Developer	Description
Pentium	Intel	Successor to the x86 family of processors. The original Pentium was followed by the release of the Pentium Pro, Pentium II, Pentium III, Pentium 4, and Pentium D.
Celeron		CPU aimed at lower cost computers. The brand name does not change with version upgrades as is customary with the Pentium series, but the processor itself has improved with each successive generation.
Athlon	AMD	Includes Athlon MP for servers, Athlon and Athlon XP for general computers, and Mobile Athlon and Mobile Athlon 4 for laptops.
Duron		CPU aimed at lower cost computers. Designed to compete with Celeron processors from Intel.
PowerPC	Motorola, IBM, Apple (alliance)	Includes the PowerPC 601, 603, 604, 740, 750, G4, and G5. PowerPC processors are equipped on Mac (Macintosh) computers from Apple.

Reference

Clock generator

A "clock generator" is a circuit that generates a clock signal.

(2)Clock frequency

A **"clock"** signal is a cyclical signal that is used to coordinate the timing of operations, either within the CPU or with outside devices. The **"clock frequency"** indicates the number of signals per second.

CPUs with the same bits can differ in throughput, depending on the clock frequency. The higher the clock frequency, the greater the capacity to process data and the faster the processing speed.

The clock frequency is indicated in **"Hz (Hertz)"** measurements. The CPU name is followed by a **"MHz (Megahertz)"** or **"GHz (Gigahertz)"** designation, as in **"Pentium 4 2.80GHz."** An 800MHz CPU performs eight hundred million operations per second.

Example calculation of CPU instruction execution count

If a computer has a CPU that operates at 200MHz, the CPU is capable of executing one machine language instruction at an average of 0.5 clocks.

Can this CPU execute several tens of thousands of instructions per second?

The number of instructions that can be executed per second is calculated as follows.
CPU clock frequency ÷ Clocks necessary to execute one instruction
= 200MHz ÷ 0.5 clocks
= 200 × 106 clocks per second ÷ 0.5 clocks per instruction
= 400 million instructions per second

(3)Bus width

A **"bus"** is a path used to exchange data between devices. The **"bus width"** indicates the number of signal lines that make up the bus, and is indicated in bit units. The devices and CPU inside of a computer are physically connected by buses.
An **"internal bus"** refers to a bus that is used to exchange data inside the CPU. A 32-bit CPU for example, exchanges 32 bits of data inside the CPU for every one clock (representing the interval in which the clock circuit sends one timing signal). An **"external bus"** connects the CPU with various devices, and is also called a **"FSB (Front Side Bus)."**

●Internal bus

An **"internal bus"** is a path of transmission used to exchange data inside the CPU.
The **"core clock frequency"** refers to the clock frequency of the internal bus.

●External bus (FSB)

The **"external bus"** is a path of transmission used to exchange data between the CPU and memory or peripheral devices.
The **"external clock frequency"** refers to the clock frequency of the external bus, and is also called the **"FSB clock frequency."**

Reference

FSB

Abbreviation for "Front Side Bus."

8-1-2 Storage device

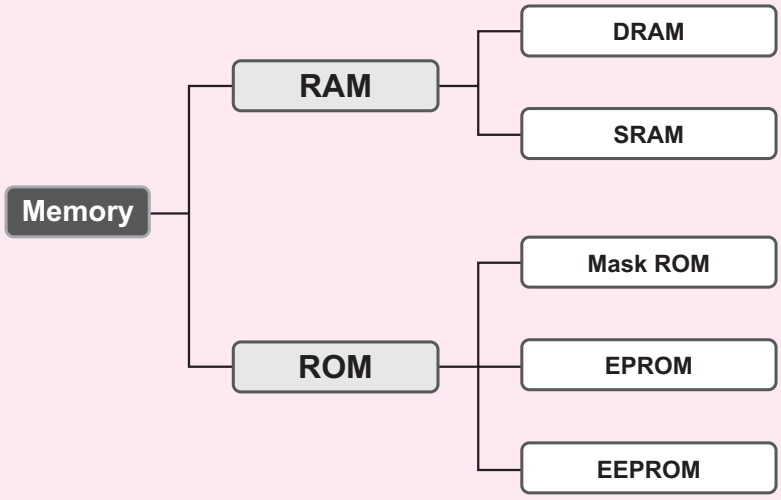
A **"storage device"** is a device that stores data including data required for computer processing.
Storage devices can be categorized into **"memory"** or **"storage media"** based on their type and function.

❶ Memory

"Memory" broadly refers to a device that is used to store programs and data required for processing in the operation of a computer. Memory relies on the use of integrated circuits (semiconductors). Also referred to as **"main memory."**

(1)Types of memory

Memory can be categorized by the method used to store data. Several methods of data storage are summarized below.



●RAM (Random Access Memory)

"RAM" is a volatile type of memory in which stored content is lost when the power is turned off. Data can be read and written, and is used as main memory or cache memory.

Comparison item	DRAM	SRAM
Capacity	Large	Small
Processing speed	Slow	Fast
Cost	Low	High
Refresh function (re-supply of electricity)	Available	Not available
Power consumption	High	Low

●ROM (Read Only Memory)

"ROM" is a non-volatile type of memory that retains stored content after the power is turned off. There are read-only ROMs for data and programs, and rewriteable ROMs used as flash memory or storage for the computer BIOS.

Type	Characteristics
Mask ROM	Data is written at the manufacturing stage and cannot be rewritten afterwards.
EPROM	Data can be written afterwards. Data can be erased using ultraviolet light.
EEPROM	EPROM that can erase data electrically. Flash memory is a typical type of EPROM that is used in digital cameras and IC cards.

Reference

RAM

Abbreviation for "Random Access Memory."

Reference

ROM

Abbreviation for "Read Only Memory."

Reference

DRAM

Abbreviation for "Dynamic Random Access Memory."

Reference

SRAM

Abbreviation for "Static Random-Access Memory."

Reference

EPROM

Abbreviation for "Erasable Programmable Read Only Memory."

Reference

EEPROM

Abbreviation for "Electrically Erasable Programmable Read Only Memory."

Reference

Flash memory

"Flash memory" is a type of EEPROM that is electrically rewriteable. For computers, flash memory is used as storage for the BIOS or as auxiliary storage device.

Reference

BIOS

"BIOS" is a program that controls the input/output between the computer unit and peripheral devices.
BIOS is stored in ROM and integrated into the motherboard.
Abbreviation for "Basic Input/Output System."

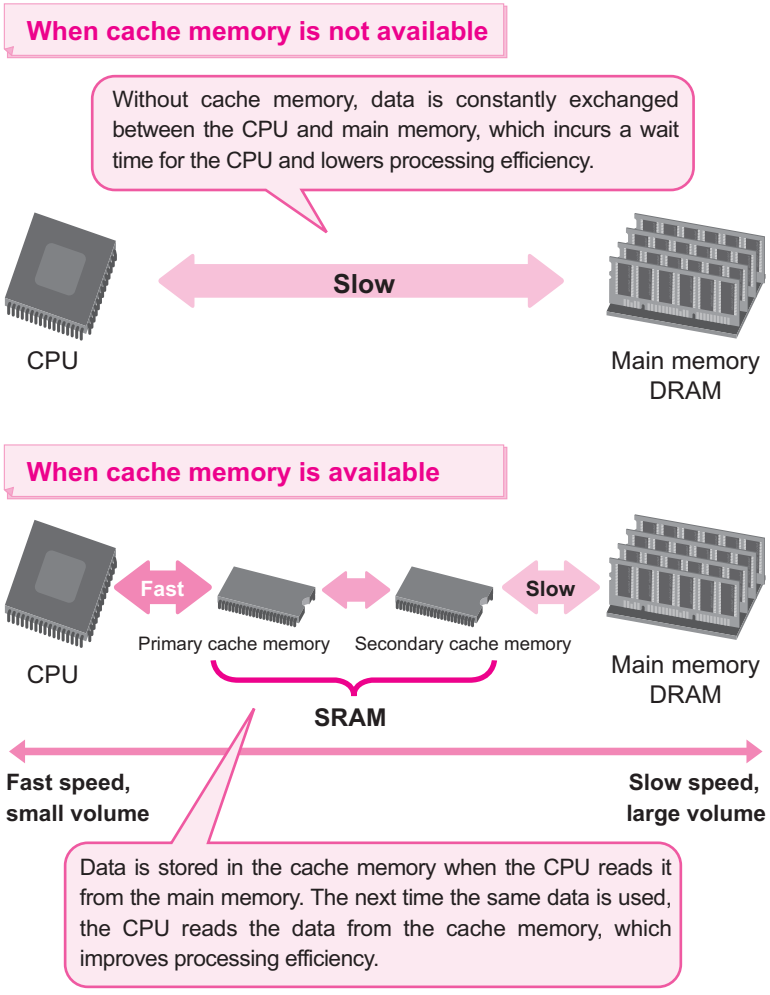
(2)Memory applications

Memory can be categorized by application. Several types of memory are summarized below.

Type	Characteristics
Main memory	Memory that stores programs and data that the CPU processes. DRAM is used for this purpose.
Cache memory	Memory used to speed up computers by absorbing the difference in the access speeds of the CPU and main memory. Many computers are equipped with multiple cache memory, which are called "primary cache memory" and "secondary cache memory" based on their proximity to the CPU. SRAM is used for this purpose.
VRAM	Dedicated memory for temporary storage of image data shown on the display. VRAM is typically provided separately from the main memory, and is integrated into graphics accelerator boards. DRAM is used for this purpose.

Due to the difference in the processing speed of the CPU (fast) and main memory (slow), **"cache memory"** is used to fill in the gap between processing speeds.

High-speed cache memory is used to store previously accessed data. Instead of accessing the slow main memory each time, the same data is next accessed by reading it from the cache memory. Faster throughput is achieved by reducing the frequency of accessing the main memory.



Reference

SIMM

Abbreviation for “Single In-line Memory Module.”

Reference

DIMM

Abbreviation for “Dual In-line Memory Module.”

Reference

Expansion memory

“Expansion memory” is memory that is added later to expand the built-in standard memory.

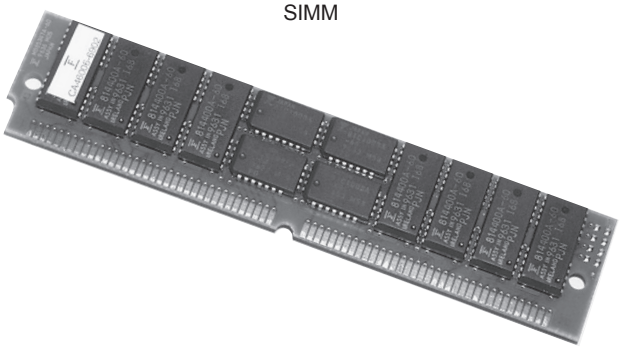
(3)Types of main memory

The type of main memory used depends on the type of computer. When expanding the main memory, it is necessary to add the correct type of main memory for the computer.

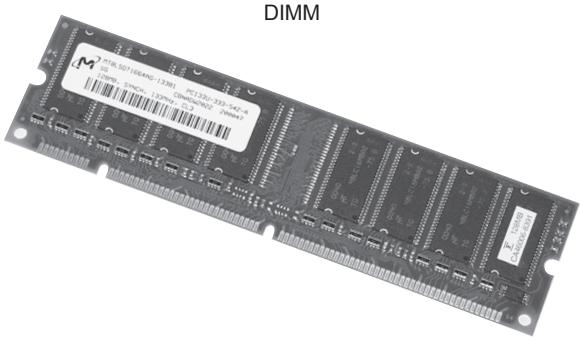
The common types of main memory are summarized in the following table.

Type	Characteristics	Data transfer
SIMM	The signal pins on the front and back of the module release the same signals. Used on desktop computers, typically in pairs. Recently declining in usage.	32-bit unit
DIMM	The signal pins on the front and back of the module release separate signals. Used in laptop PCs. Recently used as memory in desktop computers.	64-bit unit

SIMM



DIMM

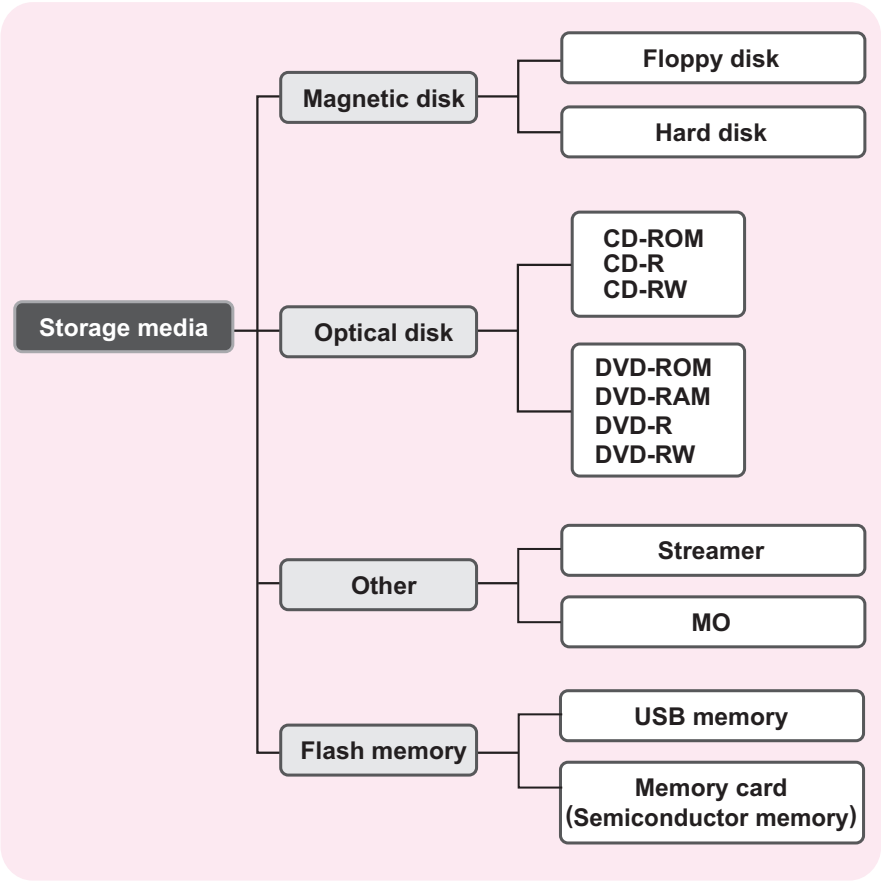


❷ Storage media

“Storage media” are devices that store created data and files, and are also called **“auxiliary storage devices.”**

The data stored on storage media is retained after the power is turned off, making it possible to carry the data around and distribute it. Storage media also have a large storage capacity, and can be used to save data and programs.

The following are types of storage media.



(1)Magnetic disk

A **"magnetic disk"** is a type of storage media that uses magnetization to read and write data.

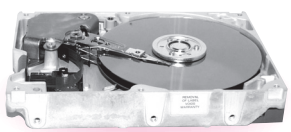
The characteristics and storage capacities of typical types of magnetic disks are summarized below.

Storage device	Storage media	Characteristics	Storage capacity
FDD (Floppy Disk Drive)	Floppy disk	Reads and writes data to floppy storage media comprising of a plastic case that contains a thin, magnetic-coated film disk.	720KB 1.44MB
HDD (Hard Disk Drive)	Hard disk	Reads and writes data to storage media comprising of multiple magnetic-coated metal disks. The standard storage media used for computers.	Tens of GB (gigabytes) to several TB (terabytes)

*Approximate capacities as of May 2009.

Floppy disk

Hard disk



Reference

Track

A "track" is a concentric region for data storage that is separated on a magnetic disk.

Reference

Sector

A "sector" is a region of data storage that is derived by radially dividing a track into equal parts. It is the smallest storage unit of a magnetic disk.

Reference

Cylinder

A "cylinder" comprises a group of tracks that share the same location. Each storage surface has its own magnetic head. These heads move in line with each other simultaneously, which makes it possible to select tracks on the same radius. The groups of tracks on the same radius comprise a cylindrical shape or cylinder.

Reference

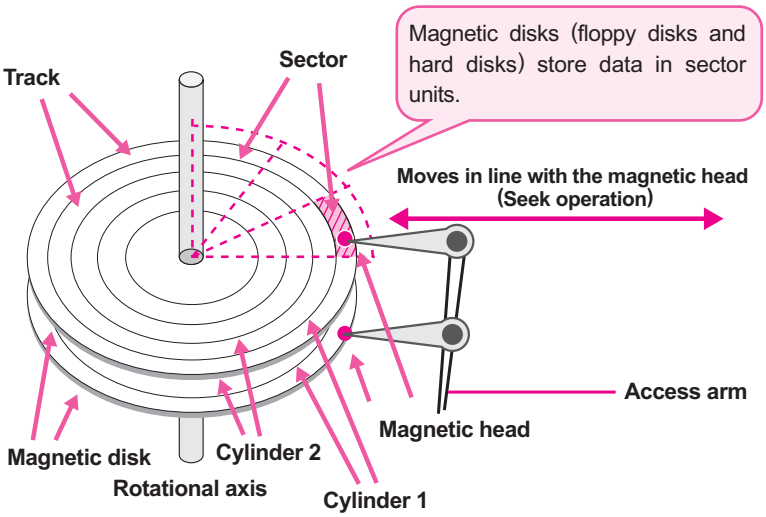
Search time

"Search time" refers to rotational latency for read/write operations on a magnetic disk. It is the time it takes after the seek operation has finished, for the magnetic disk to rotate, and for the lead part of the read data or write area to reach the position of the magnetic head. The seek operation time is called "seek time."

●Construction of magnetic disks

In order to use a magnetic disk, it is first necessary to **"format (initialize)"** the disk. The formatting organizes the disks into **"tracks"** and **"sectors"** to enable the storage of data.

The construction of a magnetic disk is shown below.



●Sequence for read/write operations of magnetic disks

Magnetic head moves to the target track. (Seek operation)

↓

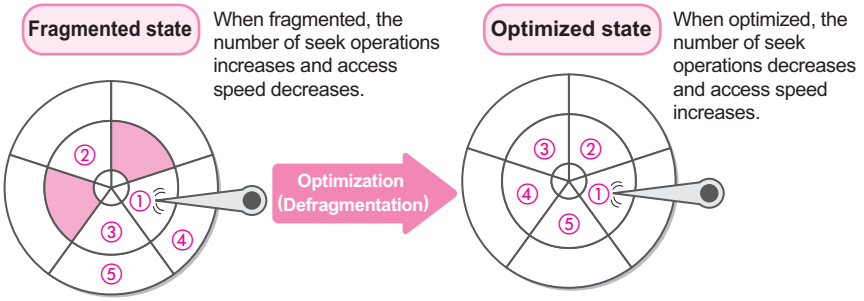
Waits for the target sector to rotate and come around. (Rotational latency)

↓

Reads and writes to and from the target sector. (Data transfer)

●Fragmentation and optimization (defragmentation)

"Fragmentation" occurs when data is stored across multiple regions of the hard disk. Repeatedly adding, deleting, and moving data that is stored across a continuous sector results in a state of fragmentation. When data becomes fragmented, the number of seek operations increases, which in turn reduces access speed. It is then necessary to periodically repair fragmentation via **"optimization,"** which is performed using specialized software.



●Calculating the capacity of magnetic disks

The following formula can be used to calculate the storage capacity of a magnetic disk, and the number of sectors needed to record data.

Formula for calculating storage capacity

Storage capacity per sector × No. of sectors per track × No. of tracks per surface × No. of storage surfaces

Example

If a floppy disk with the following specifications is formatted, how many MB is the storage capacity?

No. of tracks per surface	**: 80**
No. of sectors per track	**: 18**
Sector length (bytes)	**: 512**
Storage surface	**: Both sides**

512 bytes × 18 sectors / per track × 80 tracks / per surface × 2 surfaces = 1,474,560 bytes ≒ 1.4MB

Therefore, the storage capacity is 1.4MB.

Formula for calculating number of sectors needed to store data

Data length ÷ Storage capacity per sector ··· Round to nearest integer

Example

For a floppy disk that has 512 bytes per sector, how many total sectors are needed to store 500 bytes, 1,400 bytes, and 1,600 bytes of data?

500 bytes ÷ 512 bytes = 0.976 ···· (rounded to nearest integer) = 1 sector

1,400 bytes ÷ 512 bytes = 2.734 ···· (rounded to nearest integer) = 3 sectors

1,600 bytes ÷ 512 bytes = 3.125 ···· (rounded to nearest whole integer) = 4 sectors

1 sector + 3 sectors + 4 sectors = 8 sectors

Therefore, 8 sectors are needed.

Reference

CD-ROM

Abbreviation for "Compact Disc Read Only Memory."

Reference

CD-R

Abbreviation for "Compact Disc Recordable."

Reference

CD-RW

Abbreviation for "Compact Disc Rewritable."

Reference

DVD-ROM

Abbreviation for "Digital Versatile Disc Read-Only Memory."

Reference

DVD-RAM

Abbreviation for "Digital Versatile Disc Random Access Memory."

Reference

DVD-R

Abbreviation for "Digital Versatile Disc Recordable."

Reference

DVD-RW

Abbreviation for "Digital Versatile Disc Rewritable."

Reference

Shelf life of optical discs

Data on optical discs is protected by a thin resin protection layer on top of the recording layer where data is stored. Using an optical disc for many years can result in deterioration of the protection layer and loss of the stored content.

(2)Optical disks

An **"optical disk"** is a type of storage device that uses laser optics to read and write data.

The characteristics and storage capacities of typical optical disks are summarized below.

Storage device	Storage media	Characteristics	Storage capacity
CD-ROM drive	CD-ROM	A read-only media. Due to its low cost, CD-ROMs are widely used to distribute software packages.	650MB 700MB
CD-R drive	CD-R	A media that reads and writes data. Data can only be written once, after which the data becomes read-only. Also referred to as a "write once, read many disc." Data that is recorded to a CD-R can be read by CD-ROM devices.	
CD-RW drive	CD-RW	A media that reads and writes data. Can be rewritten about 1,000 times.	
DVD-ROM drive	DVD-ROM	A read-only media that is widely used to distribute movies and other large-volume video software.	Single-sided, single-layer: 4.7GB Single-sided, dual-layer: 8.5GB * Capacities are doubled for double-sided media
DVD-RAM drive	DVD-RAM	A media that reads and writes data. Used to record large-volume video from devices such as digital video cameras.	
DVD-R drive	DVD-R	A media that reads and writes data. Data can only be written once, after which the data becomes read-only. Data that is recorded to a DVD-R can be read by DVD-ROM devices or DVD players.	
DVD-RW drive	DVD-RW	A media that reads and writes data. Can be rewritten about 1,000 times, similar to a CD-RW.	
Blu-ray drive	Blu-ray	A media that reads and writes data. The Blu-ray format was jointly developed by a consortium of nine companies including Sony and Panasonic. Uses the same 12-cm diameter optical disc cartridges as CDs and DVDs. Used as a large-capacity storage media for data such as video.	Single-sided, single-layer: 25GB Single-sided, dual-layer: 50GB

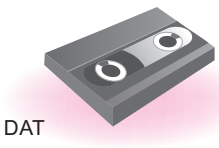
*Approximate capacities as of May 2009.

(3)Other

Storage media other than magnetic discs and optical discs are summarized below.

Storage device	Storage media	Characteristics	Storage capacity
Streamer (Magnetic tape drive)	Magnetic tape	A streamer continuously reads and writes data, whereas magnetic tapes typically used with general purpose computers are started and stopped as each block is read and written. Magnetic tape formats include "DAT" and "8mm tape." For computers, DAT tape is mainly used to perform operations such as backing up data.	Several tens of to several hundred GB
MO device (Magneto-optical disk drive)	MO	Writes data using laser optics and magnetism, but only uses laser optics for reading data. Capable of repeated rewriting.	Several hundred MB to several GB

*Approximate capacities as of May 2009.


DAT


MO

(4)Flash memory

"Flash memory" is a non-volatile type of rewriteable memory that retains stored content after the power is turned off.

Several types of flash memory are summarized below.

Storage media	Characteristics	Storage capacity
USB memory	Reads and writes data using flash memory. Integrated with a connector for connecting to a computer, offering small size and excellent portability.	Several tens of MB to several tens of GB
SD memory card	Reads and writes data using flash memory. Used in digital cameras and mobile phones.	Several tens of MB to several tens of GB

*Approximate capacities as of May 2009.

Reference

Sequential access

"Sequential access" is a method of reading and writing data in sequence starting from the first position of a file.

Reference

Random access

"Random access" is a method of reading and writing from an arbitrary point in a file.

Reference

DAT

Abbreviation for "Digital Audio Tape."

Reference

MO

Abbreviation for "Magneto-Optical disk."

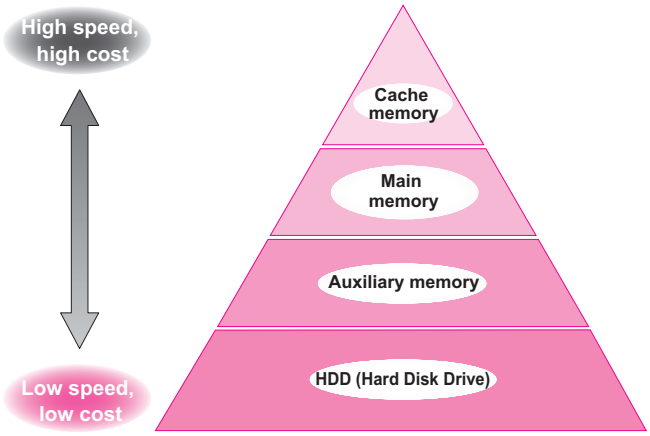
Reference

Compact flash memory card

A "compact flash memory card" is a type of storage media that reads and writes data using flash memory. They are used in digital cameras and portable laptop computers.

❸ Storage hierarchy

A **"storage hierarchy"** uses a pyramid-shaped hierarchy diagram to represent the structure of storage devices used by a computer. Normally, storage devices are stacked in order of data access speed; storage devices with slower data access speed are at the bottom, while storage devices with faster access speed are at the top. The farther up the pyramid, the closer in proximity to the CPU.



8-1-3 Input/Output devices

A computer can be connected to peripherals such as printers and scanners. In order to connect the peripherals, the type of **"interface"** used must match.

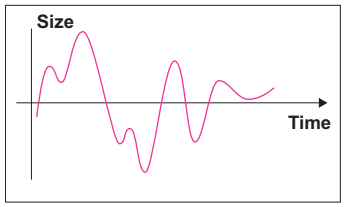
❶ Input/Output interfaces

An **"input/output interface"** is an intermediary device or system for exchanging data (electrical signals) between two points such as a computer and peripheral.

The types of data exchanged between a computer and peripheral are summarized below.

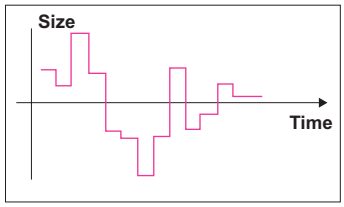
●Analog

"Analog" information is expressed as a continuous value. Changes occur in a wave-like pattern since time is continuous. Attenuation and noise become more pronounced as the transmission distance increases.



●Digital

"Digital" information is expressed as a concrete numerical value. Changes occur in a bar graph pattern due to numerical value conversion. Digital information is not prone to attenuation and noise as the transmission distance increases.



A computer processes information based on electrical signals that have been converted into numerical values. In other words, a computer handles and processes digital information. In the exchange of electrical signals between a computer and peripheral, the interface acts as an intermediary. Input/output interfaces used for data transmission are divided into **"serial interfaces"**, **"parallel interfaces"**, and **"wireless interfaces."**

Reference

PC/AT-compatible computers

A “PC/AT-compatible computer” is a computer that is compatible with PC/AT computers made by U.S.-based IBM Corporation.
The “IBM PC/AT” computer specification was released in 1984. Many hardware manufacturers produced computers according to this specification, and it is now a global standard for computers.

Reference

Bus power method

“Bus power method” is a method of supplying power to USB equipment over a USB cable. USB equipment that does not need an AC adapter or power cord is operable simply by connecting a USB cable and receiving power via USB.

Reference

bps

“bps” refers to the amount of data that can be transferred in one second. Abbreviation for “bits per second.”

(1)Serial interface

A **“serial interface”** is an interface that transfers data one bit at a time. It uses few signal lines and is not prone to signal variation, making it suitable for long-distance transmission.
The standards for serial interfaces are summarized below.

Standard	Characteristics
RS-232C	An interface used to connect a computer unit to a modem or mouse. They are standard and built into PC/AT-compatible computers.
USB	An interface used to connect various types of peripherals such as a keyboard, mouse, printer, or display. A USB hub can be used to connect up to 127 peripherals. While the power is on, peripherals can be connected or removed (hot plugging), and power can also be supplied to them over a cable. Data transmission speeds range from 1.5Mbps for low-speed mode (USB 1.1) to 480Mbps for high-speed mode (USB 2.0).
IEEE1394	An interface used to connect devices such as a digital video camera or DVD-RAM. Up to 63 peripherals can be connected. It enables hot plugging and power to be supplied. Also referred to as “FireWire” and “i.Link.”

RS-232C

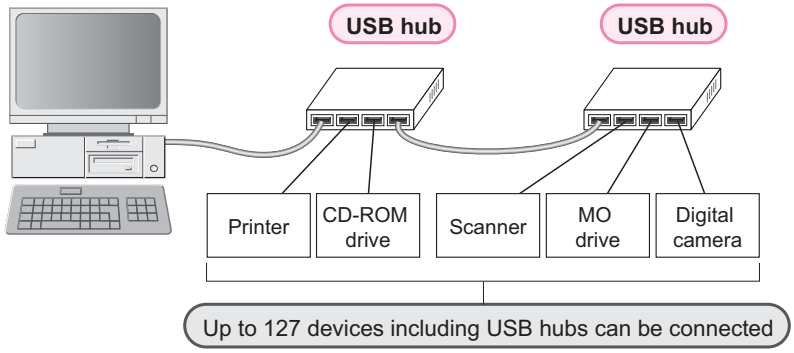
D-sub 25-pin

D-sub 9-pin

USB

IEEE1394

USB connection example



* Printers and other peripherals can also be directly connected to the USB port of the computer unit.

(2)Parallel interface

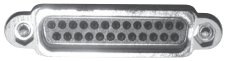
A **"parallel interface"** is an interface that transfers data in groups of multiple bits.

Since it bundles signal lines and sends data in parallel, it is prone to signal variation. This makes it unsuitable for long-distance transmission.

The standards for parallel interfaces are summarized below.

Standard	Characteristics
IEEE1284	An interface mainly used to connect a computer unit to a printer. In addition to printers, it is also used to connect image scanners and MO devices.
SCSI (pronounced "scuzzy")	An interface used to connect a computer unit to peripherals. It is mainly used when connecting external peripherals. Up to seven peripherals can be connected in a daisy chain method in which each piece of equipment is connected in series. (The daisy chain can comprise up to eight pieces of equipment including the SCSI board of the computer unit.) Depending on the SCSI standard, up to 15 pieces of equipment (or 16 including the SCSI board of the computer unit) can be connected.

IEEE1284

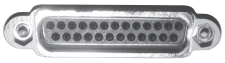


D-sub 25-pin

Amphenol 36-pin

SCSI

Amphenol 50-pin

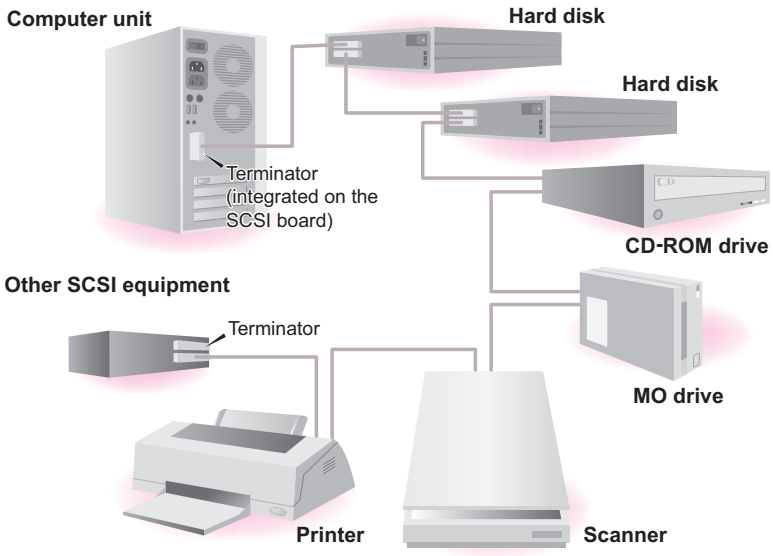


D-sub 25-pin

Amphenol half pitch 50-pin

Comb-shaped Amphenol half-pitch 50-pin

SCSI connection example



Reference

PCMCIA

"PCMCIA" is a U.S. standardization organization that develops standards and specification for items such as PC cards.

There are various types of PC cards including SCSI cards and LAN cards. PC cards transmit data using a parallel transfer method.

Abbreviation for "Personal Computer Memory Card International Association."

Reference

Terminator

A "terminator" is a kind of resistance that is connected so that electrical signals are not reflected back at the end of a daisy chain of peripherals. Also referred to as a "terminating resistance."

Reference

SCSI ID

A "SCSI ID" is a number from 0 to 7 that is used to identify equipment connected by a SCSI interface. The SCSI ID can be assigned to SCSI equipment in any order.

Reference

IrDA

Abbreviation for "Infrared Data Association."

Reference

Device

A "device" is a peripheral that is connected to a computer such as a keyboard, mouse, or display.

Reference

Plug and play

"Plug and play" is a function of Windows that automatically configures the optimum settings for a peripheral when it is added to a computer. Necessary device drivers for the connected device are automatically added and configured. In order to activate it, plug and play must not only be supported by the computer, but also by the peripheral.

Up to seven peripherals can be connected by a daisy chain method. A **"terminator"** is attached to the equipment at each end of the daisy chain as resistance. (A SCSI board contains a built-in terminator.)

Each piece of SCSI equipment must be configured to have a unique ID number. If the SCSI IDs overlap, there can be issues such as the peripherals failing to operate.

(3)Wireless interface

A **"wireless interface"** is an interface that transfers data using infrared or wireless transmission technology. Transmission speeds can range from fast to slow, but the distance of transmission is short at several tens of meters. Wireless interfaces are therefore generally suited for short-range use such as indoors.

Standards for wireless interfaces are summarized below.

Standard	Characteristics
IrDA	An interface that uses infrared communication. The transmission distance is generally within two meters. If there are obstructing objects between the devices, interference can occur in the data transmission.
Bluetooth	A wireless communications interface that uses the 2.4GHz band to achieve transmission speeds of 1Mbps within a range of 10 meters. Integrated into computers, printers, PDAs, and mobile phones. Relatively resistant to obstructing objects compared to IrDA.

❷ Device driver

A **"device driver**," also called a **"driver**," is a piece of software that enables the use of a peripheral. Every peripheral requires a device driver, which must be installed to use the peripheral. Device drivers must be developed to support the type of operating system and type of computer, and are either provided with the device or can be downloaded from the Web site of the manufacturer.

However, the latest operating systems are **"plug and play**," which enables peripherals to be used simply by connecting them.

8-2 System component

8-2-1 System configuration

An **"information system"** is a system that uses a computer to advance work activities.
Information systems can be categorized according to the type of computer used or processing mode. When developing systems, it is necessary to select a system configuration that matches its purpose.

1 Processing modes for information systems

The processing modes for information systems are summarized below.

(1)Centralized processing

"Centralized processing" is a processing mode in which all processing is performed by a single computer (host computer). It is the processing mode employed by online systems.
The characteristics of centralized processing are summarized below.

- **One computer is used for management, making it possible to focus equipment and personnel.**
- **Easy to conduct operations management, security management, and maintenance.**
- **If there is a failure with the computer that performs the processing, the overall system comes to a halt.**

(2)Distributed processing

"Distributed processing" is a mode in which processing is divided between multiple computers connected by a network. It is the processing mode employed by client/server systems.
The features of distributed processing are summarized below.

- **Easy to expand the system functions.**
- **If there is a failure with a single computer, the overall system comes to a halt.**
- **Processing is performed by multiple computers, increasing the complexity of operations management, security management, and maintenance.**
- **If an abnormality occurs, it can be difficult to trace the location of the abnormality.**

Reference

Online system

An "online system" is a system configuration that uses a communication line to connect between computers and perform processing.

Reference

Client/server system

Refer to "Chapter 8-2-1 4 Client/server system."

Reference

Standalone

"Standalone" is a system configuration in which a single computer performs processing without connecting to a network.

Reference

Workstation

Refer to "Chapter 8-4-1 Hardware."

Reference

Parallel processing

"Parallel processing" is a method for improving the overall throughput of a system by connecting multiple computers to perform a single processing task.

Reference

Cluster system

A "cluster system" is a system configuration in which multiple computers (including servers) are connected by a network, operating together as if it were a single system. It is one type of system configuration that seeks to improve reliability by continuing to provide services without interrupting tasks in the event of a failure.

Reference

Handling of primary and secondary systems

Depending on how the secondary system is handled, there are two types of duplex systems.

●Cold standby system

The primary system usually performs real-time processing, while the secondary system performs other processing such as batch processing. Depending on the separate processing performed by the primary and secondary systems, a duplex system can be effectively employed.

●Hot standby system

The primary and secondary systems do not perform separate processing, and the secondary system is maintained in the same state as the primary system as a backup. This makes it possible to quickly switch systems in the event of a failure.

In terms of hardware configuration, distributed processing can be categorized into **"horizontal distribution"** and **"vertical distribution."**

●Horizontal distribution

"Horizontal distribution" is a processing mode in which processing is distributed by connecting computers and workstations with standalone processing capabilities.

●Vertical distribution

"Vertical distribution" is a processing mode in which the functions are distributed by connecting a hierarchy of computers and terminals that perform the processing.

❷ Information system configuration

The typical configurations for information systems are summarized below.

(1)Dual system

A **"dual system"** uses two systems with the same configuration, which simultaneously perform the same processing to check whether there are errors in the processing results. If a failure occurs, the system that generated it is isolated and the other system continues the processing.

(2)Duplex system

A **"duplex system"** uses two systems; one system is used as the primary system (currently used system), and the other is used as the secondary system (backup system). The primary system usually performs the processing. If a failure occurs with the primary system, the duplex system switches to the secondary system to continue the processing that the primary system was performing.

(3)Thin client

A **"thin client"** manages resources such as application software and files on the server side, and limits the client-side computer to only the minimum functions. On the client side, the system can be operated simply by preparing network functions for connecting to the server and input/output functions. This makes operations management easy to conduct, and offers enhanced security.

❸ Uses of information systems

The uses of information systems are summarized below.

(1)Interactive processing

"Interactive processing" is a form of mutually interactive processing between the user and computer. The user responds to the operations requested by the computer through the display, mutually performing the processing as if actively interacting with the computer.

(2)Real-time processing

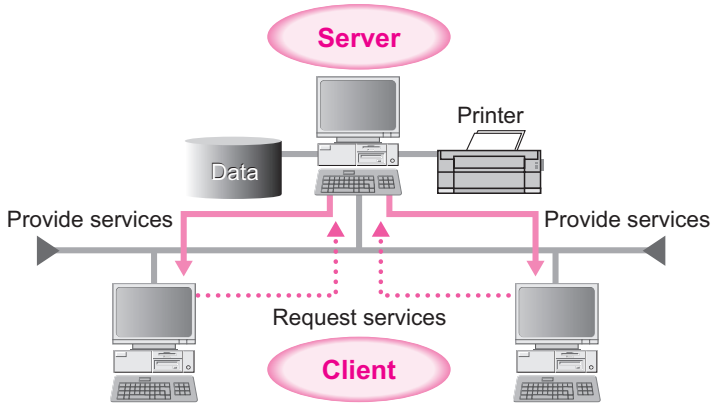
"Real-time processing" is a mode in which processing occurs the instant data is generated. It is used in conjunction with online systems such as bank ATM and train seating reservation systems.

(3)Batch processing

"Batch processing" is a mode that accumulates data over a specified period and processes it in batches. Batch processing is automatically performed simply by configuring the processing settings, which allows it to be employed when the computer is normally not in use. It is used for administrative processing such as pay calculations.

4 Client/server system

A **"client/server system"** is a system that is configured by designating the roles of a **"server"** and **"client."** A server provides services to computers that are connected to the network, while a client requests services from the server.



(1)Characteristics of client/server systems

The characteristics of a client/server system are summarized below.

Characteristic	Description
Reduced load on system	Roles are divided (processing is distributed) between client and server, reducing the load on the system.
Reduced installation cost	Use of hardware resources (printers, hard disk drives, etc.) is shared, reducing installation costs.
Improved efficiency of work	Use of software resources (files, etc.) is shared, improving work efficiency by retrieving necessary data when needed and processing.
Ease of system expansion	Servers and clients can be added easily.
Increased complexity of system management	Hardware and software resources must be managed for each server and client, increasing complexity the more the scale of the system increases. Also difficult to isolate the cause and responsibility if an issue arises.

Reference

Peer to peer

"Peer to peer" refers to a type of system that comprises a network. In a peer to peer system, computers connected to the network are mutually connected as equals, instead of designating individual roles. For this reason, there is no distinction between servers and clients.

Reference

Web system

A "Web system" is a system that operates on a server and performs two-way communications using a browser. "Shopping carts" seen on many shopping sites and "e-mail forms" are a type of Web system applications.

Reference

Network printer

A "network printer" is a printer with built-in print server functions. Laser printers widely used in corporations are a type of network printer. Clients can use a network printer simply by connecting the printer to a hub. However, a printer driver must be installed for each client.

Reference

Database management system

Refer to "Chapter 9-3-1 Database architecture."

(2)Types of servers

In a client/server system, servers can be categorized according to their role. The types of servers are summarized below.

Type of sever	Description
File server	A server that collectively manages files. Clients can share files on the file server for effective use of information.
Print server	A server that manages and controls a printer. Clients temporarily save print data to the hard disk of the printer server (spooling), and after it is registered to a printing queue, the data is printed in sequence.
Database server	A server with a DBMS (Database Management System). It can produce an environment similar to one in which all clients are directly connected to the database. According to the requests of the client, the database server performs processing such as searching, tabulating, and sorting large amounts of data, and returns only the results to the client.

(3)Three-layer architecture

A **"three-layer architecture"** is a system that divides the applications of a client/server system into three modules.

In a three-layer architecture, data is processed on the server side to limit the amount of data transferred between the client and server.

Dividing the applications into three modules also makes it easier to change the specifications.

A conventional and typical client/server system is called a **"two-layer architecture."**

Hierarchy of three-layer architecture

First layer	Presentation layer	Human interface level
Second layer	Application layer (Function layer)	Data processing level
Third layer	Data layer	Database access level

8-2-2 System evaluation indexes

System evaluation indexes require a comprehensive look at the computer performance, reliability, and cost efficiency.

1 System performance

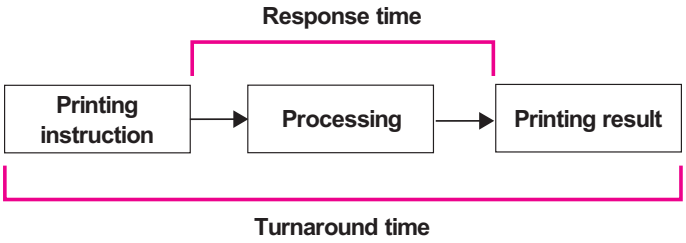
System performance is measured by conducting a **"performance testing"** as part of system testing and acceptance testing. A performance testing is a test used to verify whether aspects of processing such as response time, turnaround time, and benchmarks satisfy requirements.
The aspects used to evaluate the performance of a system are summarized below.

(1)Response time

The **"response time"** is the time it takes for the computer to first respond from the time the computer is requested to perform a given process. It is used to evaluate the performance of online systems. Response time is affected by CPU performance and number of connected users. Lower loads produce faster response times, while higher loads produce slower response times.

(2)Turnaround time

The **"turnaround time"** is the time it takes to receive all processing results from the time the computer is requested to perform a series of tasks. It is used to evaluate batch processing performance.



(3)Benchmark

A **"benchmark"** is an index used to measure system performance.
It compares and evaluates the performance of multiple computers by measuring aspects such as response time and CPU availability.

Reference

Throughput

"Throughput" refers to the amount of work that a system can perform in a unit of time.

❷ System reliability

When installing a system, it is important that the system is reliable for users (system user departments). System reliability is improved by ensuring the system remains operational with no functions coming to a halt during operation.

(1)Index for system reliability

"Availability" is used as an index for measuring system reliability. The system availability is a percentage that indicates the level of uninterrupted availability. The higher the availability value, the better the reliability of the system.

Availability can be indicated by **"MTBF (Mean Time Between Failures)"** or **"MTTR (Mean Time To Repair)."** A higher MTBF or shorter MTTR indicates better system availability.

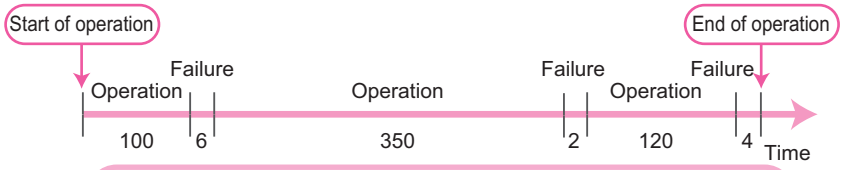
The following formulas are used to calculate availability using MTBF and MTTR.

$$\text{Availability} = \frac{\text{MTBF}}{\text{MTBF} + \text{MTTR}}$$

OR

$$\text{Availability} = \frac{\text{Total operational time} - \text{Failure time}}{\text{Total operational time}}$$

MTBF	Time between failures. Average time of continuous system operation.
MTTR	Average time to repair the system in the event of a failure.



MTBF: (100 + 356 + 120 hours) ÷ (3 times) = 190 hours

MTTR: (6 + 2 + 4 hours) ÷ (3 times) = 4 hours

Availability : $\frac{\text{MTBF}}{\text{MTBF} + \text{MTTR}} = \frac{190}{190+4}$

=0.9793814 … Approx. 0.979

OR

$\frac{\text{Total operational time} - \text{Failure time}}{\text{Total operational time}} = \frac{570}{570+12}$

=0.9793814 … Approx. 0.979

Reference

MTBF

Abbreviation for "Mean Time Between Failures."

Reference

MTTR

Abbreviation for "Mean Time To Repair."

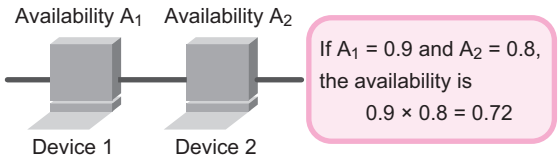
(2)Availability of complex systems

For systems that are configured from multiple computers or equipment, the formula used to calculate availability depends on whether a system is a **"serial system"** or **"parallel system."**

●Availability of serial systems

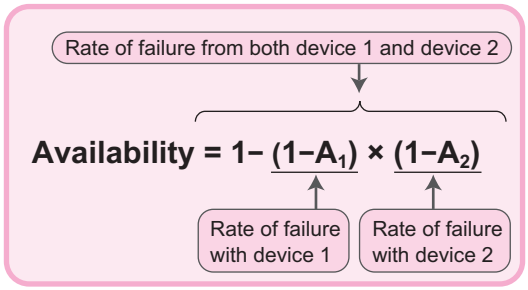
A **"serial system"** is a system that only operates when all of the devices from which it is configured are operational. If there is a failure with even one device, the system is unable to operate.

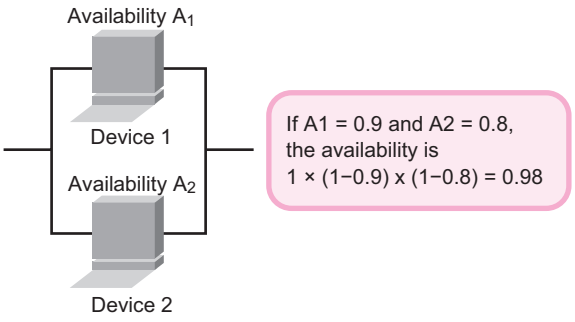
$$\text{Availability} = A_1 \times A_2$$



●Availability of parallel systems

A **"parallel system"** is a system that operates as long as at least one device is operational. The system stops operating only when all of the devices from which it is configured have failed.





Reference

Failure rate

The "failure rate" is the rate representing the number of failures that occur within a given time.

$$\text{Failure rate} = \frac{1}{\text{MTBF}}$$

Reference

Hot site

A "hot site" is a backup site equipped with equivalent servers and functions of the original site to enable rapid switchover in the event of a failure. Backup data and updated information are transferred to the backup site. This is in contrast to a "cold site," wherein a backup system is installed and made operational in the event of a failure.

(3)High reliability design

Concepts for constructing high reliability systems that users can be assured of using at all times are summarized below.

Concept	Explanation
Fault tolerant	Maintains all of the normal functions even in the event of a failure, allowing for processing to continue. Generally achieved by building a duplex system.
Fail soft	Maintains the minimum necessary functions in the event of a failure, preventing the system from coming to a complete halt.
Fail-safe	Secures the safe condition of a system in the event of a failure, and limits the resulting impact. For example, if there is a failure with a signal, the system acts to prevent the failure or malfunction from leading to an accident by turning all the signals red and stopping the vehicle.
Foolproof	Ensures against failure, even if the system is used in a way beyond the scope of the original specifications.

Reference

TCO

Abbreviation for "Total Cost of Ownership."

3 Cost efficiency of systems

When installing a system, corporations must consider aspects of cost efficiency such as evaluation and benefits.

The installation of a system entails a wide variety of costs including initial costs and operational costs. In considering the cost efficiency of a system, it is necessary to emphasize **"TCO (Total Cost of Ownership),"** which covers all necessary costs from the time of the system's purchase to its disposal.

TCO encompasses all costs including the purchase cost for computer hardware and software, training costs for users (system user departments), operational costs, system maintenance costs, and cost of losses due to system issues. It is used in the decision-making process for systems installation.

In considering the cost efficiency of a system, it is important to take into account the continuous return on investment based on the TCO calculated throughout the software life cycle.

Reference

Initial cost

"Initial cost" refers to the cost required to install a system.

Initial costs include the purchase cost for hardware and software, development labor costs (outsourcing costs), training costs for users (system user departments), and maintenance costs.

Reference

Operational cost

The "operational cost," also called the "running cost," refers to the cost required to operate a system. Operational costs include equipment maintenance costs (such as leasing fees, rental fees, upgrade costs, and labor costs for system administrators) and business losses from a shutdown of operations.

8-3 Software

8-3-1 OS (Operating System)

An OS (Operating System) is the minimum software that is needed to run a computer. Software other than the OS expands the range of application for a computer.

1 Needs of an OS

The **"OS"** is the software that manages and controls the hardware and application software. Also referred to as **"basic software."**
It acts as an interface between the hardware and software, and performs functions such as configuring settings to run software, and relaying information from the user to displays, printers, and other peripherals.
In contrast, **"application software"** such as word processing software and spreadsheet software are used for specific purposes.
The types of software that comprise a computer are categorized below.

Type		Description	Examples
System software	Basic software	Software that manages and controls hardware and application software. Usually called an "OS." In broader terms, it includes utility programs and language processors.	OS Utility program Language processor
	Middleware	Software that operates between the OS and application software. Provides basic functions that are commonly used in many areas of application.	Database management system Communications management system Operations management tool Software development system
Application software	Common application software	Software that is commonly used for a variety of industries and work.	Word processing software Spreadsheet software CAD/CAM Statistical software Graphics software Groupware
	Specific application software	Software that is used for specific industries and work.	Payroll calculation software Financial accounting software Sales management software Production management system

Reference

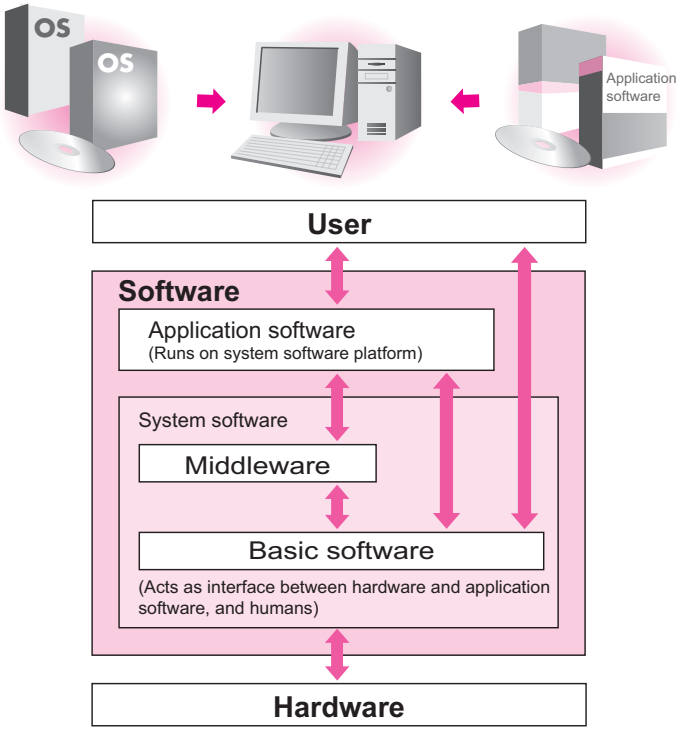
OS

Abbreviation for "Operating System."

Reference

Utility program

A "utility program" is software that enables a computer to be used more efficiently by improving the functions or operability of a computer. Examples include disc compression and optimization software, memory management software that supplements OS functions, and screensaver and anti-virus software. Also referred to as a "service program."



Reference

Virtual memory

"Virtual memory" is a function that uses a portion of auxiliary storage devices such as hard disks to execute large programs that exceed the main storage capacity. When executing multiple programs at the same time, or editing large data such as an image file, memory can be insufficient. In such a case, some of the data in the main memory is temporarily saved to a hard disk or other device, effectively providing more memory than the physical capacity of the main memory.

Reference

Profile

A "profile" is a collection of information for each user account that is unique to each environment. It manages settings such as the desktop layout, network configuration, and human interface configuration.

Reference

User account

A "user account," also referred to as an "account," is a collection of information such as a user name or password that is required to utilize a computer. A user account is linked to a single profile, and when the user logs on to the user account, the computer reads the information in the profile.

Reference

Multitask

"Multitask" refers to the CPU function in which multiple tasks are executed at the same time. Multitasking enables multiple programs including word processing software and spreadsheet software to run at the same time, and allows alternation between the two programs.
In contrast, a CPU that can only execute one task at a time is considered to be "single-tasking."

❷ OS functions

The functions of an OS are summarized below.

Function	Description
Memory management	Manages the memory domain for efficient memory use. Virtual memory enables more memory to be used than physically available.
Resource management	Allocates and manages computer resources (CPU, memory, hard disk, software) for efficient use of resources.
Input/output management (Device management)	Manages and controls peripherals such as a keyboard or printer. Recent OSes are "plug and play" to enable the easy use of peripherals.
File management	Enables reading and writing of files in devices such as hard disks and floppy disks. Restrictions on file and folder usage within the computer can be placed for each user.
User management	Enables registration and deletion of multiple user accounts on a computer. Information such as access rights and profiles are managed for each registered user account.
Task management	Manages the programs that are currently in operation. The execution unit of a program is called a "task." Recent OSes possess the capability to multitask, and are able to perform multiple tasks at the same time.

❸ Types of OSes

Several types of OSes used on personal computers are summarized below.

Type of OS	Description
MS-DOS	A single-tasking OS developed by Microsoft that runs on 16-bit CPUs in PC/AT-compatible computers. Employs a CUI (Character User Interface) operating environment.
Windows 98/ Me/NT/2000/ XP/Vista	A multitasking OS developed Microsoft that runs on 32-bit CPUs in PC/AT-compatible computers. Employs a GUI (Graphical User Interface).
MacOS	An OS developed for the Macintosh line of computers by Apple. First OS to achieve a GUI operating environment for personal computers.
UNIX	A multitasking OS developed by Bell Labs of AT&T. A CUI operating environment is standard, but a GUI operating environment is also available by installing the X Window human interface. Offers multitasking, multiple users (operating at the same time), and excellent network functionality.
Linux	An OS compatible with UNIX, developed from the ground up for use on PC/AT-compatible computers. Published as OSS (Open Source Software), which allows anyone to freely modify or redistribute the software, provided that they observe certain rules. In the strictest sense, Linux refers to the kernel of the OS. Linux is usually distributed in the form of "distributions" that packages the kernel with application software.

8-3-2 File management

When managing files, data must be adequately maintained and protected in preparation for the following situations.

- As the number of files increases, there is a tendency to forget where data is stored, and the disk can run out of available space.
- Necessary data is accidentally deleted.
- Server data is accidentally overwritten or intentionally falsified.

Etc.

❶ Directory management

"Directory management" is the process of managing files using a hierarchy structure in order to facilitate file searching. Within the hierarchy, the uppermost directory is called the **"root directory,"** while the directory below is called a **"sub-directory."**

Reference

CUI

A "CUI" is an environment for operating a computer by inputting instructions called "commands" via a keyboard.
Abbreviation for "Character User Interface."

Reference

GUI

A "GUI" is a visual environment for operating a computer via a mouse or other input device by clicking on a section of graphics called an "icon."
Abbreviation for "Graphical User Interface."
Refer to "Chapter 9-1-1 Human interface technology."

Referencev

OSS (Open Source Software)

Refer to "Chapter 8-3-4 OSS (Open Source Software)."

Reference

Interaction between different OSes

Each OS has its own rules regarding files, folders, and file names. In some cases, this may result in files that do not display properly or other issues.

Reference

Current directory

The "current directory" refers to the respective directory in which operations are currently being performed.

Reference

"." symbol

Indicates the current directory when specifying the relative path.

Reference

".." symbol

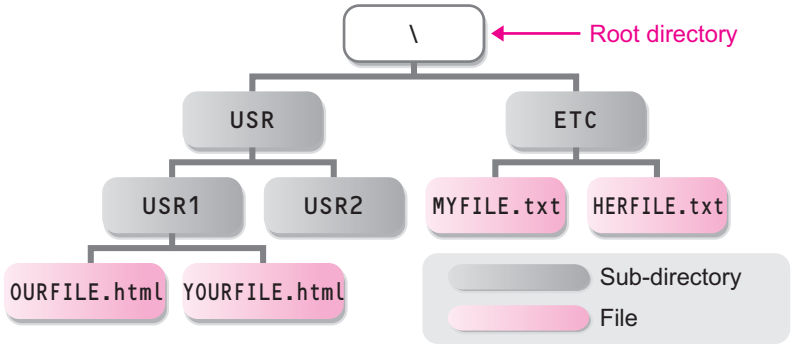
Indicates one directory above the starting directory when specifying the relative path.

Reference

Directory notation method

The notation method for directories depends on the OS. Sometimes, a slash ("/") or backslash ("\") may be used.

A directory employs a tree structure shown below.



The two ways to specify the location of files based on these file management methods are summarized below.

●Current directory is "USR"

Specifying method	Description	Specify MYFILE.txt
Specify relative path	Specify the location of the target file from the perspective of the current directory.	..\ETC\MYFILE.txt
Specify absolute path	Specify all directory names and file names in hierarchical order from the root directory to the target file.	\ETC\MYFILE.txt

❷ File sharing

When building a network, it is possible to enable file sharing so that multiple users can share and use files on computers that are part of the network. For example, in a corporation, it possible to save files such as business negotiation records and client information to a computer that is equipped with a large-capacity hard disk, and share them so that all employees concerned can access this information.

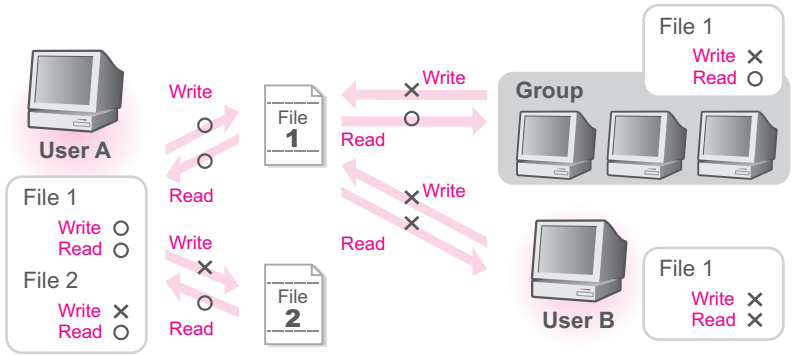
When sharing directories and files on a network, it is necessary to set **"access rights"** to restrict the read and write activity for each user.

Reference

File management

The following operations are also effective for file management.

- File optimization (defragmentation)
- File organization (deletion of unnecessary files)



3 Backup

A **"backup"** refers to a copy of data comprised of files and programs that is stored on an auxiliary storage device as protection against loss of data from computer or disk device failure. In such an event, lost data can be recovered from the backup.

The following considerations should be taken when backing up data.

- **Back up data regularly on a daily, weekly, or monthly basis.**
- **Schedule a suitable time to back up data such as after business processes are finished so that everyday work is not interrupted.**
- **For backup media, consider the time and cost the backup will require, and choose one that can store all the backup data.**
- **It is normal practice to create primary and secondary backup files, and store them in separate places to protect against file loss.**

(1)Backup files

Attempting to back up every file and registry on a personal computer is time-consuming and requires media with a large capacity.

Since Windows and application software can be reinstalled and restored to their initial state, it is normal practice not to back up either software.

Important files created by users and files that contain environment settings are usually backed up.

However, the entire hard disk is backed up if a failure will cause major ramifications.

(2)Choosing a backup method

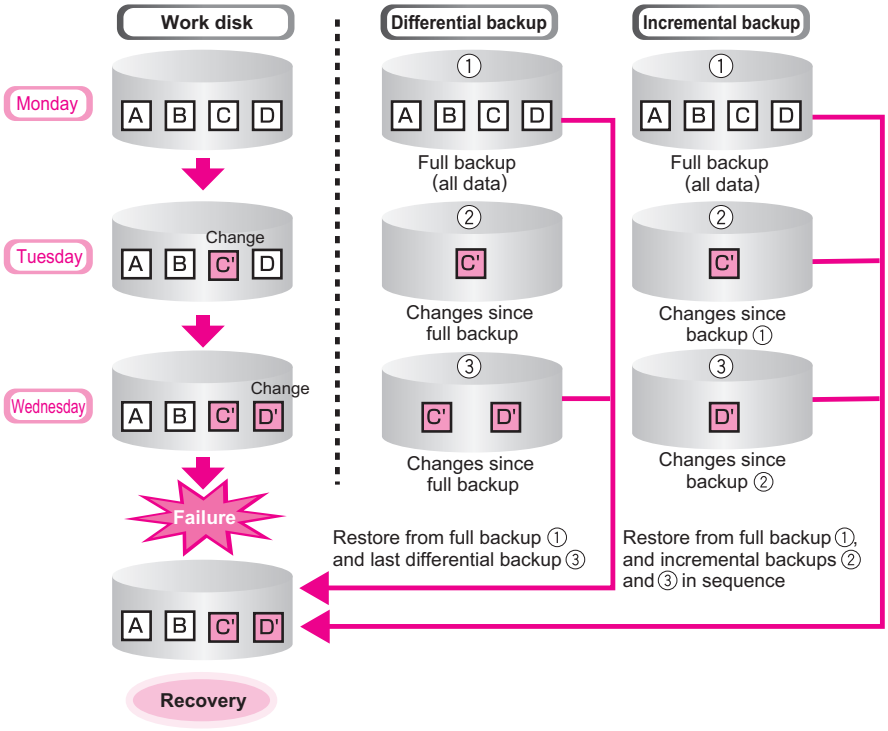
Methods of backing up data based on recovery time and backup work load are summarized below.

Type	Backup data	Recovery method	Backup time	Recovery time
Full backup	All data on the disk.	Restore from full backup.	Long	Short
Differential backup	Data that has changed since the last full backup.	Restore from full backup and last differential backup.		
Incremental backup	Data that has changed since the last backup.	Restore from full backup and all incremental backups performed since the full backup.	Short	Long

Reference

Restore

"Restore" refers to returning content that has been backed up on a disk device or other device.



(3)Backup methods

Important files are saved to a separate drive or backup media. In addition, backing up the entire C: drive allows for quick recovery of files in the event of an emergency such as damage to the hard disk.

Method	Description
Copy files and folders	Create backups by dragging and dropping each file or folder, or by copying and pasting.
Utilize backup tool	Create backups by using specialized application software.

(4)Backup media

Backup media is selected according to the volume of backup files or their application.

Examples of media formats that can be used for backup include hard disks, MO, CD-R, CD-RW, DVD-R, DVD-RW, and DAT.

Reference

Generation management

"Generation management" refers to the process of storing several generations of backup data from the past. Backup data is needed when recovering data, but if it is accidentally overwritten, older data may become necessary. In such an event, generation management is useful.

Reference

Backups that use DAT

"DAT" is a type of magnetic tape that is suited for backing up entire hard disks. Instead of individual files, whole disks are backed up.

8-3-3 Development tools

Software packages such as office suites are used for work purposes. It is useful to understand the characteristics and basic methods of operating such software, in order to use them efficiently for your work.

❶ Software packages

"Application software" refers to software that is used for a specific purpose or work.

There are various types of application software, many of which are sold as software packages. Compared to software developed from the ground up according to specific corporation or user requests, software packages are developed at a comparatively low cost, and sold to many and unspecified corporations and users.

Application software in software packages used on personal computers are summarized below.

Type	Characteristics
Word processing software	Software used to create, edit, and print documents.
Spreadsheet software	Software used to perform calculations such as tabulation, and create graphs by entering data and formulas into a worksheet.
Database software	Software used to collect, manage, and apply various data.
Graphics software	Software used to produce drawings or edit photographic images.
Presentation software	Software used for visualization via inserting drawings, graphs, tables, and photographs into presentation documents.

❷ Word processing software

"Word processing software" is software used to create documents that offers extensive functions for printing and enhancing the readability of documents. Expressive documents can be created by setting the style format of characters, and using tables, drawings, and diagrams.

The main features of word processing software are summarized below.

(1)Create documents

Documents are created by inputting character strings using an input method. The inputted character strings can be formatted by configuring settings such as the font, font size, and underlining. Other settings such as centering, indenting, and bullets can be used to change the positioning of character strings and paragraphs.

(2)Create tables

Tables are easily created by simply specifying the number of columns and rows. It is also possible to insert or delete columns and rows, or change the column width.

(3)Embed drawings, graphic objects, and tables

Expressive documents can be created by embedding drawings and graphic objects.

Reference

Multimedia authoring tools

A "multimedia authoring tool" is software used to create multimedia content that combine elements such as images, sound, and characters.

Reference

Plug-in

A "plug-in" is a program that adds features to application software, and expands the functionality of the original application software. It is possible to upgrade only the plug-in, or uninstall it.

Reference

Word processing software

Examples of word processing software include "Microsoft Word" from Microsoft and "Ichitaro" from JustSystems.

Reference

Clipboard

A "clipboard" is an area used to temporarily store data during moving or copying operations.

Data from the clipboard can be pasted any number of times once the data has been moved or copied to the clipboard.

Reference

Spreadsheet software

Examples of spreadsheet software include "Microsoft Excel" from Microsoft and "Calc" from Sun Microsystems.

Reference

Cell

A "cell" is a section of a grid in a worksheet that is divided into columns and rows.

For example, the cell in column A or row 1 is called cell "A1."

Reference

Inputting formulas

- Input a formula using numbers and operator symbols
  Example =10+20+30
- Reference cells with inputted numbers and input a formula using operator symbols
  Example =C5+D5+E5
- Input a formula using a function
  Example =SUM (C5:E5)

Reference

Cell reference

A "cell reference" refers to the referencing of a specific cell or range of cells. When a formula is inputted using a cell reference, and the data inputted into the cell is changed, the calculation result is automatically re-calculated.

A cell reference can be a "relative reference" or an "absolute reference." The "$" character can be added to the cell address to specify an absolute reference and fix the cell reference.

Example =SUM ($C$2:$C$4)

❸ Spreadsheet software

"Spreadsheet software" is integrated software that offers a variety of functions from spreadsheet and graph creation to data management. Tables and graphs are created by inputting characters, numbers, and formulas such as functions into a worksheet. It is suited for complex data analysis, and is used to analyze sales with budgeting and pricing models, as well as create forms and slips such as quotations and invoices.

The main features of spreadsheet software are summarized below.

(1)Spreadsheet functions

Spreadsheet software can easily perform calculations by inputting formulas into cells that use functions and operator symbols. Data can be selected, added, deleted, and inserted as well as formatted, to create tables that are easy to understand.

The main operator symbols and functions used in spreadsheets are summarized below.

●Operator symbols

Operator symbol	Calculation performed	Formula example	Formula entered
+ (Plus)	Addition	2+3	=2+3
− (Minus)	Subtraction	2−3	=2−3
* (Asterisk)	Multiplication	2×3	=2*3
/ (Slash)	Division	2÷3	=2/3
^ (Caret)	Exponentiation	2^3	=2^3

●Functions

Function	Calculation performed	Formula entered
SUM	Sum of numbers	=SUM(C2:C4)
AVERAGE	Average of number	=AVERAGE(C2:C4)
COUNT	Count of numbers	=COUNT(C2:C4)
MAX	Maximum value	=MAX(C2:C4)
MIN	Minimum value	=MIN(C2:C4)

(2)Graphing functions

Graphs can be easily created using data that has been inputted into cells. Graphs can be used to visually represent data, and are useful for comparing data and analyzing trends.

Various types of graphs such as vertical and horizontal bar graphs, line graphs, and pie charts are included in spreadsheet software.

(3)Database functions

A **"database function"** is a function that is used to manage and operate a database containing related data such as a product list, employee list, or sales log.

Database functions can be used to efficiently management large amounts of data.

Database functions are summarized below.

●Sort

Sorts data according to the specified criteria.

●Filter

Filters only the data from the database that meets the conditions.

4 Presentation software

"Presentation software" is software used to create persuasive and high-impact presentations through the use of tables, graphs, diagrams, animations, and audio in addition to explanatory text. It can be used to make effective presentations for a variety of situations including briefings for various project plans such as sales plans, and announcements of new products.

The main features of presentation software are summarized below.

Reference

Presentation software

Examples of presentation software include "PowerPoint" from Microsoft, and "Agree" from JustSystems.

(1)Create slides

Files are in slide format, making it possible to input titles for each slide, or input text using bullets. The design, font, and other attributes used in the slides can also be changed.

(2)Expressive presentations

Graphs can be inserted in order to visually express numerical data. Also, drawings and images taken with a digital camera also be inserted, and graphics such as lines, ellipses, and balloons can be created.

5 WWW browser (Web browser)

"WWW (World Wide Web)" refers to a service that is used to view and search information from **"Web pages"** on the Internet. Web pages are collections of information published on the Internet. In order to obtain information from the Internet, the Web page a user wishes to view is accessed.

Software referred to as a **"WWW browser"** is used to view Web pages.

The main features of a WWW browser are summarized below.

Reference

WWW

Abbreviation for "World Wide Web."

Reference

WWW browser

Examples of WWW browsers include "Internet Explorer" from Microsoft, "Netscape" from Netscape, and "Firefox" from Mozilla Japan.

(1)View Web pages

In order to view a Web page, a **"URL"** is specified from the WWW browser. A URL, also simply called an **"address,"** is a convention for displaying a Web page address.

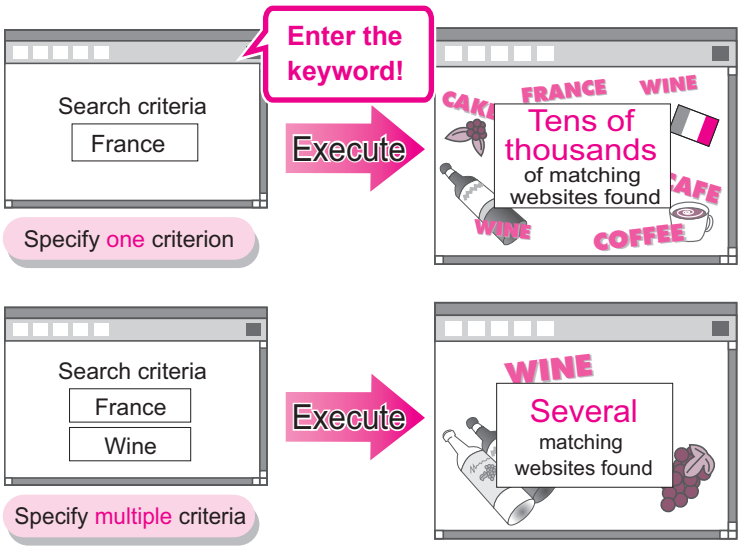
Reference

URL

Abbreviation for "Uniform Resource Locator."

(2)Search Web pages

A **"search engine"** is utilized when the address of a Web page a user wishes to view is not known. The user simply enters or selects a keyword using the search engine to display matching Web pages. If many Web pages match the keyword, additional keywords can be added to narrow the search.



The following search methods are used when specifying multiple keywords.

Operator	Description	Example
AND	Search that includes both "France" and "wine"	France AND wine
OR	Search that includes "France" or "wine"	France OR wine
NOT	Search that includes "France" but not "wine"	France NOT wine

8-3-4 OSS (Open Source Software)

OSS (Open Source Software) is software that is freely modified and distributed by many persons, used around the world.

❶ Characteristics of OSS

"OSS" refers to software wherein the source code is published over the Internet free of charge by the creator, making it possible for anyone to modify or redistribute the software without infringing on copyrights.

Corporations normally distribute software for a charge to prevent creation of imitation products that mimic the technology used in the software. As a rule, OSS offers no warranties, and is freely redistributed without charge, with the aim of encouraging development of the software.
Characteristics of OSS are summarized below.

- Allows users to redistribute freely.
- Allows distribution of the source code.
- Allows distribution of derivative software.
- Protects the integrity of the original source code.
- Does not discriminate against individuals or groups.
- Does not discriminate against the field of use.
- Does not require an additional license to redistribute.
- No dependency on specific software.
- No limitation on other software distributed on the same media.
- No dependency on a specific technology or interface.

❷ Types of OSS (Open Source Software)

The major OSS applications are summarized below.

Category	OSS	Description
Office	OpenOffice.org	An office suite that includes word processing and spreadsheet software. Compatible with Microsoft Office data, and can handle Word files, Excel files, etc. Comprised of six software including "Writer (word processing software)", "Calc (spreadsheet software)", "Impress (presentation software)", "Draw (drawing software)", "Base (database software)", and "Math (formula editor software)."
Internet	Firefox	Internet software that can display a WWW browser. Similar operating feel to Internet Explorer from Microsoft, and allows for numerous add-on programs to be installed.
E-mail	Thunderbird	Software for sending and receiving e-mail. Similar operating feel to Outlook Express from Microsoft. Also offers functions for organizing received messages and privacy protection.
Image editing	GIMP	Image editing software with advanced functions similar to Photoshop from Adobe. Although it does not an offer an extensive range of standard options or designs, it can be used to create and edit highly sophisticated graphics.

Other examples of published OSS include the **"Linux"** OS and **"MySQL"** database management system.

Reference

Source Code

"Source code" is the code from which software is created via a programming language. In order to run software, it is necessary to create a program from the source code.

Reference

OSI

"OSI" is an organization whose purpose is to promote OSS. OSI defines the terms under which programs are distributed as OSS.
Abbreviation for "Open Source Initiative."

8-4 Hardware

Reference

Hardware

"Hardware" refers to the actual devices that make up a personal computer.

8-4-1 Hardware

There are many types of typical hardware that make up a computer. Understanding these types and their characteristics enable hardware to be used effectively for work.

1 Computer

Computers can be organized into various categories based on their performance, purpose, shape, and size.

(1)Types of computers

Computers were originally developed for the purpose of performing science and technology calculations.

Subsequent advancements in technology have led to the spread of computers to all kinds of fields. Modern day computers are now used for a wide variety of purposes in not only corporations and research institutes, but in homes and schools as well.

Computers are categorized by performance and purpose as summarized below.

Type	Description	Applications
Supercomputer	A computer that offers the fastest speed and highest performance for high-speed processing such as science and technology calculations.	Weather forecasting, air traffic control, aerospace development, etc.
General purpose computer	A computer that is designed to be used for both office processing and science and technology calculations. Also referred to as a "mainframe."	Train seat reservations, online bank deposit systems, etc.
Office computer	A specialized computer used for office processing in corporations. Also referred to as a "business server."	Inventory control, sales management, etc.
Workstation	A high-performance computer used for specialized work. A workstation is categorized as either an "EWS (Engineering Workstation)" used for applications such as CAD/CAM and science and technology calculations, or an "office workstation" used for applications such office processing and information management. Workstations are mainly connected to LANs and used as servers. Workstations can also include high-end personal computers with high-performance processing.	Software development, CAD/CAM, servers, etc.

Reference

Microcomputer

A "microcomputer" is an ultra-small computer system that is intended for integration into equipment used for control purposes. It was originally used to refer to a computer system that is centered on a microprocessor.

(2)Types of PCs (Personal Computers)

Computers can be categorized into several types according to their layout and size as summarized below.

Type	Description		Characteristics		
			Size (Weight)	Expand-ability	Power con-sumption
Desktop	A personal computer used in a fixed location such as on a desk. Also referred to as a "stationary computer." Broadly categorized into tower, slimline, and all-in-one types.		Large	High	High
	Tower	A personal computer unit that stands upright and is relatively large.			
	Slimline	A slim personal computer unit that takes up less space.			
	All-in-one	A personal computer unit that is integrated with a display.			
Laptop	A portable personal computer that is equipped with a full keyboard, and can be directly supplied with 100V/200V AC electric power (without an AC power adapter). It gets its name from being able to sit on top of a lap and be used. A slimline desktop personal computer that uses an LCD display can also be considered a laptop. In the West, notebook computers are often called laptops.				
Notebook	A personal computer that can be folded like a notebook with an emphasis on portability, and is equipped with an LCD display and keyboard that are built into the unit. Notebook computers come in A4 and B5 sizes, as well as even smaller sub-notebooks.				
PDA	A palm-sized personal computer, also referred to as a "palmtop" computer. Mainly used to manage personal information such as addresses and schedules. Usually equipped with built-in Internet connectivity.		Small	Low	Low

Reference

PC

Abbreviation for "Personal Computer."

Reference

Rack-mount server

A "rack-mount server" is a server with a flat layout designed to be mounted on a rack. Rack-mount servers are suited for keeping and organizing multiple servers. Each server requires their own power supply and cabling.

Reference

Blade server

A "blade server" is a server in which multiple thin servers are mounted on a specialized chassis, and is suited for processing large amounts of data. The multiple servers are constructed extremely thin, and can share a power supply and cabling. This enables it to take up even less space than a rack-mount server and use less power.

❷ Input devices

"Input devices" are devices used to assign instructions and data to a personal computer.

Several types of input devices are summarized below.

Type	Nam	Description
Input device for characters and numbers	Keyboard	A standard device for inputting characters, numbers, and symbols, by pressing the keys positioned on the keyboard.
Pointing devices	Mouse	A typical pointing device for inputting positional information such as icons, by rotating a mouse ball to move the pointer on the screen. There is also an "optical mouse" that detects reflected light to gauge the amount of movement.
	Trackball	A device for inputting positional information such as icons, by rotating a ball using the fingers.
	Trackpad (Touchpad)	A device that moves a mouse pointer by brushing a finger against a flat, plastic surface. It detects changes in capacitance when a finger brushes against the trackpad. Unlike a trackball or mouse, no mechanical parts are used, making it resistant to breaking. Mainly used on notebook computers.
	Pointing stick	A device that moves a mouse pointer, by using a finger to apply pressure forward/backward/left/right against a stick that protrudes from the middle of a keyboard. The speed at which the mouse pointer is moved can be typically controlled by adjusting the force used to press the stick. Mainly used on notebook computers. Names vary by manufacturer.
	Digitizer/ tablet	A device that uses a coordinate indicator to input a position on a flat surface. It is used to input design plans and drawings. A "tablet" is a small version of this device that is used on desk. A "stylus pen" is used for input.
	Touch panel (Touch screen)	A device that inputs data by touching the fingers against icons or buttons shown on the display. Used for bank ATM and library information displays, etc.

Trackball

Trackpad

Pointing stick

Reference

Pointing device

A "pointing device" broadly refers to a device that inputs positional information (coordinate information) for the screen.

Reference

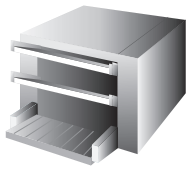
Stylus pen

A "stylus pen" is an input device that is shaped like a pen. It is used to input graphic objects and characters on a tablet or PDA.

Type	Nam	Description
Image input device	Image scanner	A device that captures photographs, pictures, printed materials, and handwritten characters as digital data. There are “flatbed”, “sheet feeder”, and “portable” scanners.
	Digital camera	Similar to a regular camera, it photographs scenery and people, but captures the images as digital data.
	Barcode reader	A device that optically reads barcodes placed on products and other items. Used as an input device for POS terminals. There are “stationary” and “portable” barcode readers.
	OCR (Optical Character Reader) device	A device that optically reads handwritten characters and printed characters. OCR for personal computers read images with an image scanner, and use OCR software for character recognition.
	OMR (Optical Mark Reader) device	A device that optically reads marks that are darkened with a pencil on an answer sheet.
Other input devices	Sound input device	A device that uses a microphone to input data or operate a personal computer by voice.
	Handwritten character input device	A device that reads characters that are handwritten on a flat device. Can also be used in place of a mouse to input positional information. Used on electronic personal organizers and notebook computers.
	Magnetic card reader	A device that reads information from magnetic stripes attached on magnetic stripe cards such as credit cards and debit cards.

Barcode reader

Image scanner



OCR

Reference

OCR

Abbreviation for “Optical Character Reader.”

Reference

OMR

Abbreviation for “Optical Mark Reader.”

Reference

CCD

A “CCD” is a semiconductor device that converts the intensity of light called a “light-sensitive element” or “pixel” into an electrical signal. Devices such as digital cameras use an array of multiple CCDs to convert and store changes in light, into independent electrical signals for each pixel. CCDs with a higher number of pixels produce more detailed images. Abbreviation for “Charge Coupled Device.”

❸ Output devices

An **"output device"** is a device that retrieves information from within a computer in a manner that is easy to understand for humans. Typical output devices for personal computers are a **"display"** and **"printer."**

(1)Display

Several types of displays are summarized below.

Type	Characteristics
CRT display	A display device that uses a CRT (Cathode Ray Tube). It comes in a variety of sizes such as 15-inch, 17-inch, and 21-inch, and basically uses the same principles as a CRT television. Although it has a high display performance, it has disadvantages such as high power consumption and the large size of the device itself.
LCD display	A display device that uses LCD (Liquid Crystal Display) technology. It ranges in size from 10 inches to around 60 inches, and employs the property of liquid crystals (light transparency changes when voltage is applied) to display images.
OLED (Organic Light- Emitting Diode) display	A low voltage drive and low power consumption display device that emits light when voltage is applied. It gets its name from the use of luminescent organic molecules such as diamine and anthracene. The low voltage drive, low power consumption, and the ability to produce thin displays make it possible to use it in the same way as an LCD display.

Reference

CRT

Abbreviation for "Cathode Ray Tube."

Reference

Pixel

A "pixel" is the smallest unit of an image, and indicates a point on a display. Also referred to as a "dot."

Reference

Multiscan display

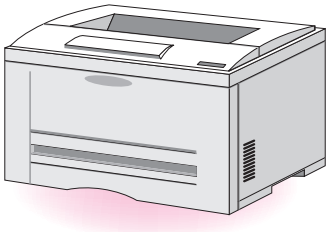
A "multiscan display" refers to a display that supports multiple resolutions.
The resolution can be changed to suit the application.

(2)Printer

Printers are categorized by the unit used to print characters and other information on paper, and divided into **"page printers"** and **"serial printers."** A page printer stores the printing pattern for a single page in the printer memory, and prints the page all at once. In contrast, a serial printer prints one character at a time.
Several types of page printers and serial printers are summarized below.

●Page Printer

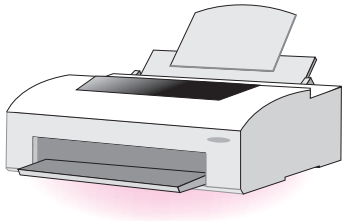
Type	Characteristics
Laser printer	A printing device that uses a laser beam and electrostatic technology to deposit toner on paper. Printers primarily used in offices due to high speed and quality of printing.



Laser printer

●Serial printer

Type	Characteristics
Inkjet printer	A device that sprays ink droplets from nozzle tips onto paper. Printers primarily suited for consumer use due to low price and high quality of color printing.
Dot impact printer	A printing device that uses a set of pins that are driven forward to form the shape of a character. An ink ribbon is positioned between the paper and pins, and the pins hit the ribbon to transfer ink. Used for printing on carbon paper.
Thermal transfer printer	A printing device that uses thermal heat to transfer the ink from an ink ribbon. Some use thermal paper instead of an ink ribbon. This type is called a “thermal printer.” Many thermal transfer printers can also be used as thermal printers.



Inkjet printer

The units used to evaluate the performance of a printer are summarized below.

Unit	Description
dpi	Indicates the number of dots per inch (approx. 2.5cm) in a straight line. Used as a unit to indicate the quality of a printer or image scanner. The higher the number, the greater the resolution. Example: 600dpi over a square inch works out to 600 x 600 = 360,000 dots.
ppm	Indicates the number of pages that can be printed per minute. Used as a unit to indicate the printing speed of a page printer.
cps	Indicates the number of characters that can be printed per second. Used as a unit to indicate the printing speed of a serial printer.

Reference

Plotter

A “plotter” is a device for printing design plans and graphics.
They are used to print drawings prepared by CAD or other software. There are various types of plotters including an “XY plotter” that prints by moving a pen in a horizontal and vertical direction, and an “electrostatic plotter” that uses the same principle as a laser printer for printing. There is also an “inkjet plotter,” which uses the same principle as an inkjet printer for printing.

Reference

PostScript language

“PostScript language” is a page description language for printers, and it is used to coordinate the printer controls and printing content.

Reference

dpi

Abbreviation for “dot per inch.”

Reference

ppm

Abbreviation for “page per minute.”

Reference

cps

Abbreviation for “characters per second.”

Reference

cpi

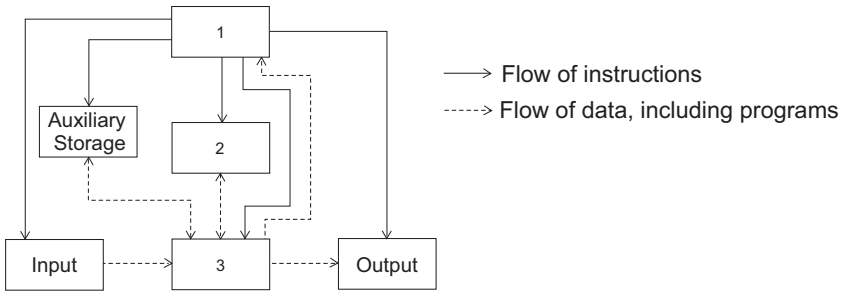
“cpi” is a unit that expresses the number of characters that can be printed in one inch.
Abbreviation for “characters per inch.”

8-5 Chapter quiz

*See page 13 in the "Answers and Explanations" booklet for the correct answers.

8-1

In the basic configuration of PCs shown below, which of the following combinations of functional units corresponds to the rectangular boxes 1 through 3?



	1	2	3
a	Control unit	Processing unit	Main memory
b	Main memory	Control unit	Processing unit
c	Main memory	Processing unit	Control unit
d	Processing unit	Main memory	Control unit

8-2

Which of the following is always required so that software can run on a PC?

a) Keyboard
b) Network
c) Printer
d) Memory

8-3 Which of the following is the memory used in SD cards?

a) CD-ROM
b) DRAM
c) SRAM
d) Flash memory

8-4 Among the connection interfaces for PCs and peripheral devices, which of the following uses electromagnetic waves for the transmission of signals?

a) Bluetooth
b) IEEE 1394
c) IrDA
d) USB 2.0

8-5 Which of the following is the configuration where the computers connected to the network use resources of each other, such as data, on equal terms?

a) Client/server
b) Streaming
c) Peer-to-peer
d) Mailing list

8-6 Which of the following is the most appropriate processing that should be performed by the server in a client/server system?

a) Processing to check the format of input data
b) Processing to display pull-down menus
c) Processing to preview printing results
d) Processing to update databases

8-7

For improvement in system reliability, there are a measure to prevent failures and a measure to continue operating the system even if a failure occurs. Which of the following is a measure to continue operating the system even if a failure occurs?

a) Replacing with the devices that do not fail easily
b) Configure redundant devices that constitute the system
c) Preparing an operation manual to prevent operators from performing incorrect operations
d) Performing operations incorporating the scheduled maintenance for the devices

8-8

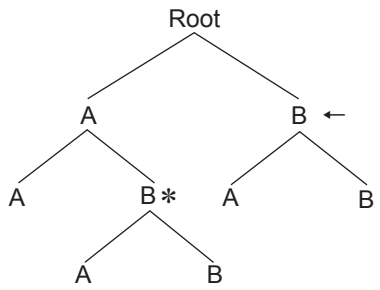
Which of the following is the appropriate description concerning an OS that runs on PCs?

a) Software that manages hardware and applications on a PC
b) Software for viewing Web pages
c) Software for transmitting and receiving e-mail
d) Software for creating and editing documents

8-9

In the hierarchical structure shown in the figure, two or more directories with the same names A and B are located. Which of the following specifies file "f" in the directory indicated by an arrow from the directory with the "*" (current directory)? Here, the file specification method is as follows:

[Specification method]
(1) Like "Directory name\... \directory name\file name", place the directories on the path by using "\" as a delimiter in correct order and then place "\" and the file name.
(2) Indicate the current directory with "." (one dot).
(3) Indicate the parent directory (one level up within hierarchy) with ".." (two dots).
(4) When it begins with "\", the root directory is omitted at the left end.



a) .\B\f
b) ..\..\B\f
c) ..\A\..\B\f
d) ..\B\f

8-10 When important files are replicated in preparation for possible hard disk failures, which of the following is the most appropriate method?

a) Replicating the files on a different hard disk, attaching version numbers to the file names
b) Finding the available hard disk space for every operation to place replicated files there
c) Replicating the files with the same file name on the hard disk used for the last replication
d) Replicating the files with different file names on the same hard disk as that storing them

8-11 Which of the following is the purpose of using a multimedia authoring tool?

a) It is used for creating multimedia content combining materials, such as images, sounds, and characters.
b) It is used for building the network environment that handles multimedia information, including images, sounds, and characters.
c) It is used for searching for multimedia information, including images, sounds, and characters on the Internet.
d) It is used for building the database that consists of multimedia information, including images, sounds, and characters.

8-12 Which of the following is a characteristic of open source software?

a) All copyrights are waived.
b) A warranty is available in case of problems.
c) Only one copy may be made for the purpose of backup.
d) The source code can be obtained.

8-13 Which of the following is the advantage of using open source software?

a) It can be used free of charge, including support.
b) There are no restrictions on modifying the source code.
c) Security is assured because there are no vulnerabilities in the software.
d) It can run on every operating system.

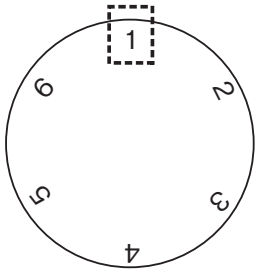
8-14

Which of the following is the input device that detects the moving direction and distance and reflects it on the cursor movement on the screen?

a) Keyboard
b) Touch panel
c) Bar code reader
d) Mouse

8-15

A disk is labeled 1 through 6 clockwise around the outer edge. The disk spins clockwise and completes a cycle once every 6 seconds. The disk is in a dark room, and only the portion on top (outlined with a dotted line here) is illuminated for a moment by a spotlight at a flashing interval of a specified period of time. Which of the following patterns of numbers can be seen when the spotlight is set to flash every 5 seconds?



a) 1, 2, 3, 4, 5, 6
b) 1, 3, 5, 1, 3, 5
c) 1, 4, 1, 4, 1, 4
d) 1, 6, 5, 4, 3, 2

Chapter

9

Technology element

Chapter 9 examines the characteristics of human interfaces and multimedia technology, basic knowledge about database design and networks, as well as security measures and other aspects.

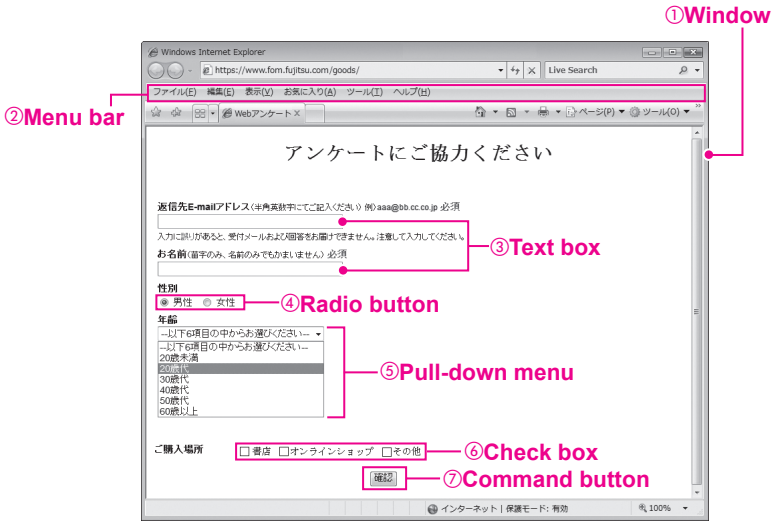
9-1 Human interface

9-1-1 Human interface technology

A **"human interface"** is the point of contact between a human and a computer. Specifically, it refers to the layout of the screen, form, and methods of operating the computer when the system is used.
During the systems architecture design stage of system development, it is important to create a human interface that considers ease of use from the user's perspective, and it is necessary to learn the techniques and procedures for designing such an interface.

1 GUI

A **"GUI"** is a human interface that makes heavy use of graphics to present information visually, and enables basic operations to be performed by using pointing devices such as a mouse.
The elements that comprise a GUI are summarized below.



***The above screen is an example from Windows Vista.**

① **Window** .....Small, stand-alone screen provided within the operational screen. Text and images are displayed here.

② **Menu bar** .....Displays menu names. When a menu name is selected, a list of corresponding commands is displayed.

Reference

Help function

The "help function" is an operational guide that provides on-screen instructions for system operations and other tasks.

③ **Text box** .....Text and number data is entered here using the keyboard.

④ **Radio button**.....One item is selected from a list of several. If a different item is selected, the previous one will be unselected automatically.

⑤ **Pull-down menu** .....Displays the selected menu by opening downward on the screen from the menu heading.

⑥ **Check box** .....Applicable items are selected from a list of several. Either a single item or multiple items can be selected. Alternatively, each individual item may have an ON and OFF option to select from.

⑦ **Command button** .....Performs the corresponding action when selected.

List box .....One or more items are selected from a list of several. Effective when there are more items than will fit in a radio button or check box list.

Icon.....A picture or symbol representing a file or command. Can be used to launch applications, open files, etc.

Pop-up menu .....A menu displayed in an arbitrary place on the screen while preserving the current contents. Also referred to as a **"short-cut menu**."

9-1-2 Interface design

Interface design can be broken down into **"screen design"** and **"form design**."

Screen design	Designs screen items and layout for data entry, and keyboard and mouse operations, etc.
Form design	Designs layout for pages and source documents, and contents to be printed, etc.

Reference

Source document

A "source document" is a form for prefilling the data to be entered on the computer. The necessary items, boxes, etc. are printed to make it easier to fill out.

Reference

Points of consideration for interface design

- Clarify the purpose of the data to be printed and the items included. Next, clarify what data must be entered for it to be printed.
- Clarify whether the user of the input screen or recipient of the form is an employee or customer, and adjust the format accordingly.
- Select an appropriate human interface according to user proficiency.
- Select the input/output device according to the contents.
- Minimize the response time and turnaround time, and take steps to ensure that a long time is not spent waiting for the data to be processed.
- Clarify how to deal with erroneous operations and system failures.
- Take steps to ensure that the data entered is not leaked outside the company.

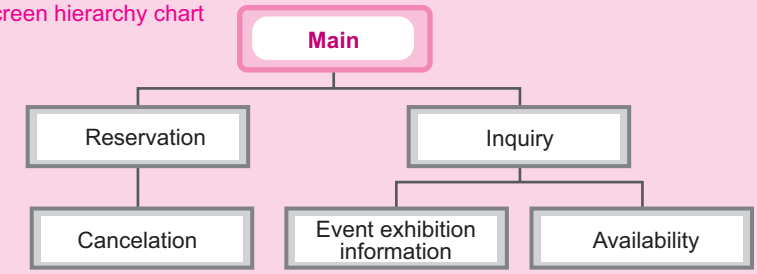
1 Screen design

The input screen is the interface most used in a system by users.
An easy-to-use input screen should be designed from the standpoint of the user.
The procedures for designing an input screen are as follows.

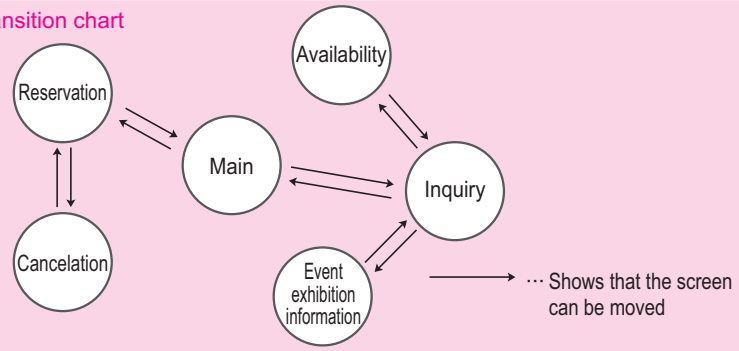
Screen standardization	Standardize the items common to each of the screens such as the position of the title and function key assignment.
↓	
Screen systematization	Design the flow and hierarchical relationship between related screens. After the screens have been systematized, create a "screen hierarchy chart" and "screen transition chart."
↓	
Screen item definition and layout design	Decide on the position of items on the screen, default values, input methods, etc.

Example: Conference room reservation system screen design

Screen hierarchy chart



Screen transition chart



Reference

Function key

A "function key" is a key on the keyboard that has been assigned a specific function. Also referred to as a "PF key." Depending on the type of keyboard, they may be given labels such as "PF1" or "F1."

Reference

Default value

A "default value" is a value that has been pre-set. When entering data, the default value can be overwritten.

Reference

Main

The "main" screen is the first screen that is displayed when using the system. All available functions are listed in the form of a menu. For this reason, it is also called the "main menu."

●Points of consideration for screen design

The points of consideration for screen design are as follows.

- **Have it move from left to right and top to bottom so that the flow of input is natural.**
- **When there are a large number of options, group them together or use some other means to make the selection easy.**
- **Establish rules for color usage.**
- **Provide an operational guide (help function) for users not familiar with the operations.**
- **According to purpose of use, make it possible to use other input devices other than a keyboard (barcode reader, touch panel, scanner, etc.).**

2 Form design

Forms used on a daily basis need to be designed in such a way that they are easy for anyone to use.

The procedures for designing forms are summarized below.

Form standardization	Standardize the elements common to each of the forms such as the position of the title and the number of lines per page.
↓	
Layout design	Design the layout of each of the items.
↓	
Selection of printer and paper	If the form is to be printed, select the printer and paper according to the purpose of use.

●Points of consideration for form design

The points of consideration for form design are as follows.

- **Place items that are common to all the forms in the same location.**
- **Include only the bare minimum information.**
- **Use commas for every three digits to make numerical data easy to read.**
- **Use tables, graphs, diagrams, etc. in the layout according to purpose.**
- **Make considerations for special output such as barcodes according to purpose.**

Reference

WYSIWYG

Abbreviation for "What You See Is What You Get," meaning that what is printed will be the same as the on-screen display.

3 Web design

It has become common practice for companies to set up their own Web pages and transmit information via the Internet. As Web pages are seen by so many people, it is not an exaggeration to say that the quality of the Web page's design can make or break the company's image. Web pages are also places to search for information on companies and submit inquiries.
It is important for Web pages to be designed in such a way that they are easy for anyone to use.

●Considerations for Web design

- **Use a style sheet and standardize the colors and design.**
- **Keep use of images to a minimum and make the operations stress-free.**
- **Avoid functions that only work on certain Web browsers and make sure the site renders properly on all browsers.**

Reference

Style sheet

A "style sheet" sets various style formats for a Web page that defines settings such as font style and size, background, and margins. A style sheet can be used to comprehensively manage a Web page, making it possible to not only set and make changes efficiently, but maintain the overall volume of the website.

4 Universal design

"Universal design" is an approach that involves designing products, equipment, facilities, and living spaces in such a way that they can be used by anyone regardless of nationality, culture, gender, age, or physical ability. Some examples include vending machines that have the product dispenser in the middle, and elevators that are entered on one side and exited on the other. These designs provide ease of use to everyone and are not limited to those in wheelchairs or those with large luggage.
This universal design approach is said to have first been proposed by Ronald Mace, a professor at the University of North Carolina in the United States, in 1985. The key point is that the target is all persons and is not limited to the elderly or people with disabilities. It is important to imagine being in the user's shoes and make designs that are accessible to as many people as possible by eliminating any inconveniences.

Reference

Usability

"Usability" refers to ease of use for a user. It is an indicator for designing a user-friendly and easy-to-use Web page.

Reference

Web accessibility

"Web accessibility" refers to the availability of the desired information and services on the website to everyone, including the elderly and disabled.

Reference

Information accessibility

"Information accessibility" refers to the removal of obstacles that get in the way of using information devices so that information can be accessed without difficulty. In general, if a device is easy to use or a screen is easy to see for people with disabilities or special needs, it will likely be easy to use or see for all users.

9-2 Multimedia

9-2-1 Multimedia technology

"Multimedia" refers to the combined use of various types of data in addition to letters and numbers, including static images, video, and audio. With advances in computer technology, the use of data such as static images, video, and audio files has become increasingly common. After converting this analog data into digital data according to certain rules, it is used in **"Web content"**, **"hypermedia"**, **"streaming"**, and other media.

1 Multimedia file types

Multimedia includes static images, video, and audio.

●Static images

The types of static image formats and their characteristics are summarized below.

File type	Extension	Characteristics
JPEG	.jpg .jpeg	A file format for compressing and storing static images. It supports 24-bit full color (16.77 million colors) images and is suited for photographs and other data that includes a wide range of colors. It is used as the image format for digital cameras and other devices. It employs lossy compression so there is deterioration in quality. The compression rate can be changed.
GIF	.gif	A file format for compressing and storing static images. It supports 8-bit color (256 colors) images and is suited for graphics and other data with limited color variation. It employs lossless compression, so there is no deterioration in quality. The compression rate cannot be changed.
BMP	.bmp	A file format for storing static images as a collection (or map) of dots. The images are not compressed, so the size of the file is relative to the size of the image and the number of colors. It is a standard format on Windows.
TIFF	.tif .tiff	A file format for storing static images. It was developed by Microsoft and Aldus (now Adobe Systems) and can save image data of different formats. Attribute information on the recording format is placed in what is called a "tag" at the top of the image data, and the image is rendered according to this information, so it can record images regardless of resolution, number of colors, etc. The user can also choose whether or not to compress the data. It employs lossless compression, so there is no deterioration in quality.
PNG	.png	A file format for compressing and storing static images. It supports 48-bit color images. It employs lossless compression, so there is no deterioration in quality.

Reference

Web content

"Web content" is a generic term that refers to information and data accessed on Internet browsers, including static images, video, audio and text.

Reference

Hypermedia

"Hypermedia" is used as a logical extension of the term "hypertext," which applies to text, and is a media format that links text, images, audio, and other objects together in an easily accessible manner.

Reference

Streaming

"Streaming" refers to a technology for efficiently distributing and playing back audio files, video, and other Web content. The data is played back while it is being downloaded, so the user does not need to wait for the download to complete. It makes it easier to watch videos and listen to music on the Internet.

Reference

PDF

"PDF" is a file format created by Adobe Systems' Acrobat software. When converting documents created using word processing software into PDF format, the data can be compressed to reduce the file size. For this reason, it is widely used for distributing electronic documents. PDF files cannot be edited using the original software.
Abbreviation for "Portable Document Format."

Reference

Compression rate

"Compression rate" refers to the ratio of data compression. The higher the compression rate, the smaller the file size.

Reference

JPEG

Abbreviation for “Joint Photographic Experts Group.”

Reference

GIF

Abbreviation for “Graphics Interchange Format.”

Reference

PNG

Abbreviation for “Portable Network Graphics.”

Reference

Capture card

A “capture card” is an extension card that can import video signals from VCRs and other devices, and convert them into digital data (video) that can be viewed on a computer.

Reference

MPEG

Abbreviation for “Moving Picture Experts Group.”

●Video

The types of video formats and their characteristics are summarized below.

File type	Extension	Characteristics	
MPEG	.mpg	A file format for compressing and storing video. It is an international standard data format for color video and audio. There are three different MPEG formats.	
		MPEG-1	Used for CDs (Video-CD), DAT, hard disks, and other media that have a data transfer speed of around 1.5 Mbps. Data is compressed and decompressed by software. Image quality is comparable to VHS videos.
		MPEG-2	Used for DVDs (DVD-Video), digital satellite broadcasts, etc. that have a data transfer speed of several Mbps to several dozens of Mbps. Data is compressed and decompressed by hardware. Image quality is comparable to HDTV.
		MPEG-4	Used for mobile communication devices (such as mobile phones), video conferencing systems, etc. that have a data transfer speed of several kbps to several dozens of kbps.
SWF	.swf	The video file format created by Macromedia’s (now Adobe Systems) Flash software. Widely used on the Internet for animated video files. A plugin (Adobe Flash Player) is required to playback video.	
AVI	.avi	A standard composite file format for videos and audio used on Windows. Software called “CODEC” that supports the various video and audio compression formats is required to play AVI files.	
QuickTime	.mov	A video file format created by Apple. Widely used not only on Macintosh, but also Windows computers. These files provide simultaneous support for various compression and decompression systems not only for audio and video, but also for text.	

●Audio

The types of audio formats and their characteristics are summarized below.

File type	Extension	Characteristics
MP3	.mp3	A file format for compressing and storing audio data using the part of MPEG-1 that controls sound. The data can be compressed to about 1/10 the size of a music CD (compression rate can be specified). It is used on portable music players and used to distribute music over the Internet.
WAV	.wav	A file format for storing raw audio sampling data in the same way as CD audio. It is used as the audio data format on Windows computers. When exporting audio files from CDs to Windows computers without compression, they are exported in WAV format. As data is not compressed, the size of data is large.
WMA	.wma	A file format for compressing and storing audio used as a standard on Windows computers. The data can be compressed to about 1/20 the size of a music CD (compression rate can be specified). It is used on portable music players and used to distribute music over the Internet.
MIDI	.midi	A file format for storing musical data such as pitch, loudness, and tone. It is used to play data created using electronic instruments (synthesizers and sound generator units) on a computer or network karaoke.
ATRAC3	.at3	A file format developed by Sony for compressing and storing audio. It is an improvement of "ATRAC," currently used in MDs, designed for use with Sony memory sticks.

❷ Compression and decompression of information

When attaching large data such as multimedia files to e-mail or publishing it on a Web page, it is common practice to **"compress"** it. The size of the file can be reduced by compressing the data.

Several files can also be put together into one, enabling data exchange to be simplified.

"Decompress" refers to returning compressed data to its original state. Compression/decompression software is used to accomplish this task.

The following are examples of data compression formats.

File type	Extension	Characteristics
Lzh	.lzh	Format of files compressed with LHA (file compression software). The compressed data can be decompressed and completely restored to its original state.
Zip	.zip	Format of files compressed with file compression software developed by PKWARE. The compressed data can be decompressed and completely restored to its original state.

Reference

MP3

Abbreviation for "MPEG-1 Audio Layer-3."

Reference

MIDI

Abbreviation for "Musical Instrument Digital Interface."

Reference

ATRAC3

Abbreviation for "Adaptive TRansform Acoustic Coding 3."

Reference

AAC

"AAC" is a file format developed by Apple for compressing and storing audio.
Abbreviation for "Advanced Audio Coding."

Reference

SDMI

"SDMI" is a file format standardized by a foundation established to protect digital music copyrights and used on mobile music players. It is used as a format for music files distributed over the Internet.
Abbreviation for "Secure Digital Music Initiative."

Reference

Archive

An "archive" is a collection of files that have been packaged together. Archives are used to free up space by compressing large files, or distribute multiple files as a single package.

Reference

Lossy compression

"Lossy compression" is a method of data compression in which the compressed images and other files cannot be completely restored to their original state when decompressing the archive.

Reference

Lossless compression

"Lossless compression" is a method of data compression in which the compressed images and other files can be completely restored to their original state when decompressing the archive.

9-2-2 Multimedia application

Multimedia technology and graphics processing are applied and utilized in various fields.

1 Graphics processing

"Graphics processing" is a task involving the display, processing, and storing of loaded images. In order to implement graphics processing, it is necessary to have an understanding of color and image quality.

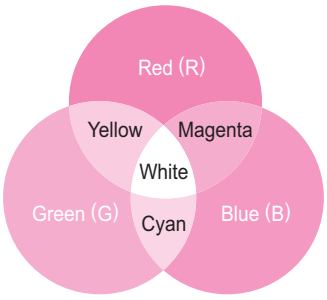
(1)Color representation

"RGB" and **"CMYK"** color models are used for displaying color on display devices and for printing in color.

●Three primary colors of light (RGB)

When displaying color on display devices, a single dot is comprised of the three colored lights Red (R), Green (G) and Blue (B). All colors are reproduced by adding together R, G and B light in varying degrees. When all three are combined, white is produced. When all three are at zero intensity, black is produced.

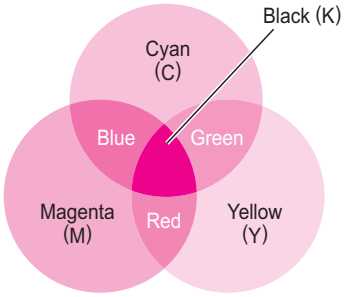
Three primary colors of light (RGB)



●Three primary process colors (CYMK)

When printing in color, the colors are created by mixing Cyan (C), Magenta (M), and Yellow (Y). When C, M, and Y are mixed, black is produced. For a solid black, Black (K) is added to create CMYK ink.

Three primary process colors (CYMK)



●Three elements of color

Colors are comprised of the three elements **"hue"**, **"brightness"**, and **"saturation."**

These three elements can be adjusted to produce various effects such as color uniformity or accented colors.

Element	Description
Hue	The color as described by wavelength. Each hue is represented on the "color circle."
Brightness	The intensity of the color. The higher the brightness, the whiter the color. The lower the brightness, the blacker the color.
Saturation	The amount of color displayed. The higher the saturation, the deeper the color. The lower the saturation, the duller the color.

(2)Image quality

Image quality is determined by pixels, resolution, and contrast.

●Pixel

A **"pixel"** refers to the dots that comprise an image and is the smallest single component of the image. The higher the number of pixels, the larger the data.

●Resolution

"Resolution" is a value that expresses the number of pixels per inch and is a measure of the detail and smoothness of the image. The higher the resolution, the more natural and attractive the image. The lower the resolution, the blurrier the image.

●Contrast

"Contrast" refers to the gradation of colors, and is a measure of the image detail. The higher the contrast, the smoother the image. The lower the contrast, the clearer the colors.

(3)Graphics software

Graphics software that handle images include **"painting"** and **"drawing"** software.

	Painting type	Drawing type
Image category	Luster	Vector
Characteristics	Pictures can be painted on the computer much like painting on a piece of paper or canvass, but the image is actually saved as a collection of dots. There are slight differences between various software applications, but they all feature intuitive tools.	Pictures are drawn by combining lines and curves into different shapes like circles and squares. The picture is smooth even when enlarged.
Typical software	Paint, Adobe Photoshop, etc.	Adobe Illustrator, etc.

Reference

Luster and vector

"Luster" refers to images created with a collection of small colored dots. "Vector" refers to images that appear as if they were drawn with a pencil; several point coordinates called "anchors" are created, and the images are produced by connecting the anchors with lines, applying color to areas enclosed by lines, etc.

❷ Multimedia technology applications

Graphics processing is an applied technology for multimedia expressions. Graphics processing involves the use of computers to create images and videos, and add sound and other effects to artificially create a sense of realism. It is used in games and other forms of entertainment as well as various professional training programs.
The typical forms of graphics processing are summarized below.

(1)Computer graphics (CG)

"Computer graphics" refers to the technology for processing and generating images and videos using a computer or the images and videos themselves.
Computers are used to create images of imaginary objects and scenes, or to add special effects.
Computer graphics can be either two- or three-dimensional representations.
Two-dimensional representations are used in tablet paintings, photographic image processing, etc.
Three-dimensional representations are used to create virtual worlds for video games, simulations of future urban landscapes, CAD-based industrial designs, etc.

Reference

CG

Abbreviation for "Computer Graphics."

(2)Virtual reality (VR)

"Virtual reality" refers to the technology for creating an artificial (virtual) reality by combining computer graphics with sound effects.
People can experience virtual realities like far-removed worlds, past and future locations, etc., as if they were actually there, while not setting foot outside their current location.

Reference

VR

Abbreviation for "Virtual Reality."

(3)Computer simulation

"Computer simulation" involves using a computer to simulate an event of some kind. Creating various simulated situations enable results to be realized that are otherwise unattainable using actual theories or experiments.
For example, it can be applied to predict damage from building fires, or the effects of global warming on climate.
The hardware and software used to perform computer simulations are called a **"simulator."**

(4)CAD

"CAD" is a system used when designing machines, buildings, electronic circuits, etc.
With recent developments in computer graphics, CAD is now used in a variety of situations.
Drawings used to be created by hand, but have now become digitalized, making them easier to edit, correct, and render into three-dimensional representations.
In addition to floor plans and blueprints for buildings and design plans for automobiles, televisions and other mechanical products, CAD is used to prepare the basic CG data used in media such as commercials and video games.

Reference

Interlaced display

"Interlaced display" refers to a method of dividing the image display operation into two parts and displaying a complete image only when the second part is displayed. It controls flickering when displaying moving images. For this reason, it is used in televisions.

Reference

Non-interlaced display

"Non-interlaced display" refers to a method of displaying a single, complete image all at once. On computer monitors and other display devices that often display static images and letters, the interlaced method tends to produce flickering and bleeding. As a result, most devices use a non-interlaced display.

Reference

Collage

A "collage" is a composite picture created using a computer to combine pictures of scenes and people that were taken separately.

9-3 Database

9-3-1 Database architecture

A database is a collection of various data (information) organized and stored in a single location according to a certain purpose. For example, product or customer information is collected and stored together in a database.
Using a database enables business activities to be expressed from the perspective of information, and makes it possible to streamline those activities.

1 Characteristics of databases

A **"database"** is a collection of data organized for a certain purpose.
In the past, data used in business activities was saved in files according to each program (process). In such a system, programs were created according to the data format. This resulted in the issue of programs not being able to respond flexibly to changes in the format of the data. To resolve this problem, databases were proposed.
A comparison of traditional files and databases is shown below.

Item	File	Database
Impact of changes to data format on program	Large	Small
Redundancy of data	Data is sometimes redundant on a task-by-task basis	No redundancy
Consistency between related data	Hard to maintain	Can be maintained
Sharing of data between tasks	Sharing is difficult	Sharing is easy
Data backup	Complicated	Simple and easy

❷ Database models

There are several models of databases depending on the format in which the data is managed.
The typical models are summarized below.

●Relational database

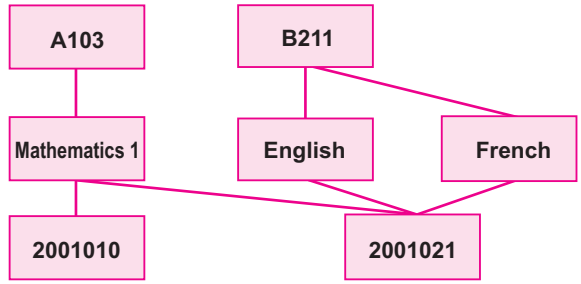
Data is managed in tables. Multiple tables are linked by item values to build a database.

Student ID	Course name
2001010	Mathematics 1
2001021	English
2001021	Mathematics 1
2001021	French

Course name	Classroom
Mathematics 1	A103
English	B211
French	B211

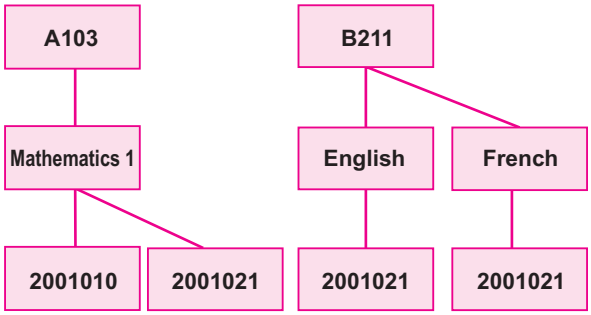
●Network database

Data is managed in a meshed format. Many-to-many parent-child relationships



●Hierarchical database

Data is managed in a hierarchical structure. One-to-many parent-child relationships comprise the data.



Reference

Characteristics of relational databases

- Related data is managed in tables.
  →Easy for users to understand.
- Tables are linked by saved "values."
  →Easy to extract the user's desired data.

Reference

Use of relational databases

Relational databases are used as the basic model for E-R diagrams.

Reference

DBMS

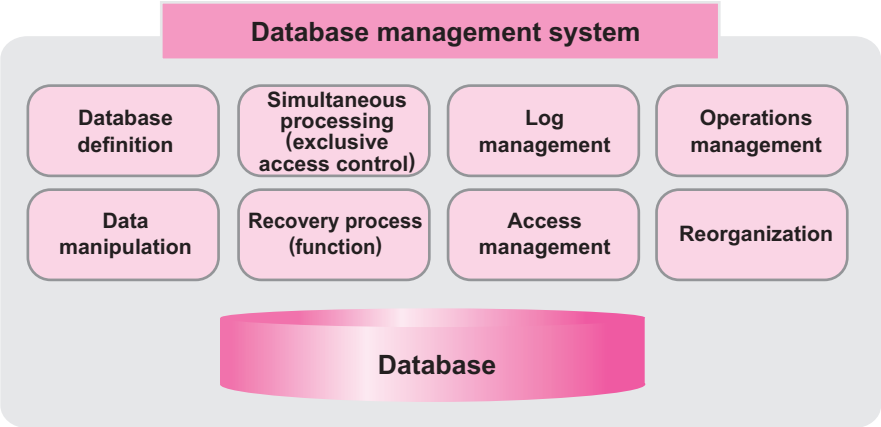
Abbreviation for "DataBase Management System."

❸ DBMS (DataBase Management System)

A database product (software) called a **"database management system"** is used to manage and manipulate databases.

The role of database management systems is to structurally store data and maintain consistency so that the user can properly use the database at any time.

The main functions of database management systems are summarized below.



Function	Description
Database definition	Standardize the operations for defining the database structure, including tables, items, and indexes.
Data manipulation	Standardize data manipulation (search, insert, update, and delete actions) with respect to the database.
Simultaneous processing (exclusive access control)	Maintain data consistency so that even if multiple users manipulate the database simultaneously, no discrepancies arise in the data.
Recovery process (function)	Restore the data to the state it was in just before experiencing hardware or software issues.
Log management	Store and manage the log files necessary for the recovery process.
Access control	Set user privileges for the database so that users without privileges cannot access the data.
Operations management	Several management-related functions including database backups and restoration, storage status, and buffer status.
Reorganization	Resolve database fragmentation resulting from repetitive adding and deleting of data. Reorganizing the database improves the speed of data manipulation.

Reference

Buffer

A "buffer" is an area of memory used to store data temporarily.

9-3-2 Database design

When designing a database, it is necessary to consider points such as **"data analysis"**, **"data design"**, and **"data normalization."**

❶ Data analysis

Before creating a database, it is important to clarify what kind of task will be converted into database format, and what it will be used for. In order to design tables in a logical manner, printing results that correspond to the purpose, and the input items necessary to obtain those results are determined.

Clarification of purpose	Analyze the flow of work and clarify the purpose of the database such as sales or inventory control. Clarify details such as how the database will be used and by whom.
⇩	
Determining printing results and input items	Determine what printing results are ultimately required and choose the input items accordingly.
⇩	
Table design	Design the tables based on the selected input items. Link the tables with common items and have them reference the data as necessary. Categorizing the input items and dividing the tables enable the construction of a database that prevents redundant data entry, unnecessary disk usage, and input error. Data is normalized to design the table.

The key points in table design are summarized below.

- **Eliminate repetitive data.**
- **Ensure that data is only registered once.**
- **Do not save data obtained through calculation in the tables.**

❷ Data design

Databases manage data in **"tables."** The table structure in databases is shown below.

Customer table

Column (field)

Item name (field name)

Customer code	Customer name	Phone number	Location
A-1	Nanboku Denki	03-3592-123X	Tokyo
B-1	Nihon Kogyo	06-6967-123X	Osaka
A-20	Iroha Denshi	078-927-123X	Hyogo

Row (record)

Primary key: Identifies each record in the table
For example, if the customer code is specified, the corresponding customer name can be identified.

If managing multiple tables, a **"relationship"** should be considered. A relation refers to linking two tables according to **"primary keys"** and **"foreign keys."**

A foreign key is used when searching for data in a different table.

For example, in the following two tables (order table and customer table), the order table does not contain the customer name. However, by linking the two tables using the customer code, the customer name can be obtained from the customer table based on the value for the customer code in the order table.

In this case, the customer code in the customer table is called the primary key, and the customer code in the order table is called the foreign key.

"Referential constraints" are used to prevent inconsistencies when setting foreign keys. For example, only a value that exists in a reference (primary key table) field can be entered in a field for which an external key has been set.

Order table

"Primary key" of order table

"Foreign key" corresponding to customer table

Order No.	Order date	Customer code	Product name	Volume
0001	2008.10.02	A-1	W-type radio	30
0002	2008.10.02	B-1	X-type monitor	20
0003	2008.10.02	B-1	Y-type radio and cassette player	100
0004	2008.10.03	A-20	Z-type radio and cassette player	5

Customer table

Items in the customer table can be referenced based on customer code

Customer code	Customer name	Phone number	Location
A-1	Nanboku Denki	03-3592-123X	Tokyo
B-1	Nihon Kogyo	06-6967-123X	Osaka
A-20	Iroha Denshi	078-927-123X	Hyogo

"Primary key" of customer table

If a referential constraint has been set, records in the customer table corresponding to customer codes (B-1, for example) in the order table cannot be deleted, and the customer code itself cannot be overwritten. Also, records containing customer codes not found in the customer table cannot be added to the order table.

●Primary key

An item set to differentiate rows from other columns in a table.
Multiple items can also be combined and made a primary key.

●Foreign key

An item in a table that is the primary key of another table.

●Referential constraint

A constraint set to maintain consistency between tables by ensuring that values that exist in the foreign key also exist in the referenced primary key.

●Index

Created to speed up data searches. An index is created with respect to items within a table specified by the search conditions.
Creating indexes speeds up database searches.
However, indexes are updated when data is updated. If indexes are created indiscriminately, the processing speed will slow down.

3 Data normalization

In order to use a database, it is necessary to determine a table format. At such time, the process of **"data normalization"** is performed. Data normalization is the process of dividing tables appropriately so that data is not duplicated.
Normalizing data eliminates redundancy, making it easier to manage data, and enables the use of data for various purposes.
Data normalization is a basic technique for building databases.
The main purposes of normalizing data are summarized below.

•Eliminate redundancy of data stored in tables.
•Set tables in a format that enables data to be manipulated using SQL statements.

Normalized tables are said to be in **"normalized form,"** and those that are not are said to be in **"non-normalized form."**

Examples of non-normalized form (grades table)

Student ID	Name	Department code	Department name	Course name	Classroom	Grade
2001010	Iuchi	R	Department of Science	Mathematics 1	A103	A
				English	B211	C
2001021	Nakahara	K	Department of Economics	Mathematics 1	A103	B
				German 2	C402	A

Repeating items = "Non-normalized"

"Course name", "classroom", and "grade" in the grades table contain several items of data.
These are called "repeating items." This grades table is yet to be normalized and is in "non-normalized form."

Reference

Normalization procedure

For "Non-normalized forms" that include repeating items, normalization is performed in three steps. These are the first normal form, second normal form, and third normal form. Data redundancy is eliminated by completing all three steps.

First normal form
Eliminate repeating items

↓

Second normal form
Move items dependent on part of the primary key to other tables

↓

Third normal form
Move items not dependent on the primary key to other tables

9-3-3 Data manipulation

Database management systems employ a standardized method of manipulation called **"SQL"** to define tables and search, insert, update, and delete data. Commands called SQL statements execute functions like data searches in an interactive fashion. SQL is standardized by ISO (International Organization for Standardization) and JIS (Japan Industrial Standards Committee), which allows for data to be handled without regard to the type of database management system.

Extracting the necessary data from the database is called an **"operation."**

Examples of operations are **"relational operations"** and **"set operations."**

Reference

Data manipulation

In addition to the three relational operations, the following are different kinds of data manipulation.

Insert ·····Insert the specified record into the table.

Delete ···Delete the specified record from the table.

Update ··Update the specified record in the table.

●Relational operation

A **"relational operation"** is an operation that extracts the desired data from a table.

There are three basic relational operations.

Project ·····Extract the specified item from the table.
Select·····Extract the specified record from the table.
Join ·····Extract data that combines two or more tables by means of a certain item with the same value.

Relational operation example

Customer code	Customer name	Rep code
2051	Ono	A12
4293	Tanaka	B30
5018	Harada	A11

Select

Customer code	Customer name	Rep code
4293	Tanaka	B30

Extract only records where the customer code is "4293"

Project

Customer code
2051
4293
5018

Extract only the customer code "item"

Customer code	Customer name	Rep code
2051	Ono	A12
4293	Tanaka	B30
5018	Harada	A11

Rep code	Rep name
A12	Suzuki
A11	Yamada
B30	Saito
B60	Yoshida

Join

Customer code	Customer name	Rep code	Rep name
2051	Ono	A12	Suzuki
4293	Tanaka	B30	Saito
5018	Harada	A11	Yamada

Join data where the "rep code" is the same in a row In this case, the "rep code" is called a "join key"

●Set operation

A **"set operation"** is an operation that extracts data using the approach of joining two tables.

The primary set operations are as follows.

Union ····· Extract all data in two tables.
Intersection ····· Extract shared data in two tables.
Difference ····· Extract data in only one of two tables.

Set operation example

Purchase Table A

Customer code	Customer name	Rep code
1311	Inoue	C01
2051	Ono	A12
4293	Tanaka	B30
1806	Mori	A11
7745	Yagi	D04

Purchase Table B

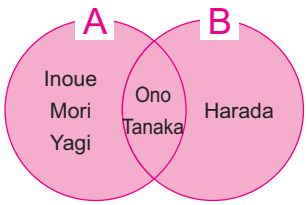
Customer code	Customer name	Rep code
2051	Ono	A12
4293	Tanaka	B30
5018	Harada	A11

Union

Data in both Purchase Table A and Purchase Table B

Customer code	Customer name	Rep code
1311	Inoue	C01
2051	Ono	A12
4293	Tanaka	B30
1806	Mori	A11
7745	Yagi	D04
5018	Harada	A11

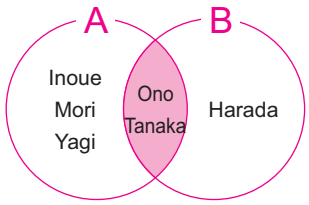
Records in both tables consolidated into one record



Intersection

Data in Purchase Table A or Purchase Table B

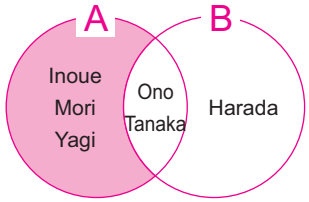
Customer code	Customer name	Rep code
2051	Ono	A12
4293	Tanaka	B30



Difference

Data in Purchase Table A minus data in Purchase Table B (data only found in Purchase Table A)

Customer code	Customer name	Rep code
1311	Inoue	C01
1806	Mori	A11
7745	Yagi	D04



Reference

Wildcard

A wildcard can be used to specify conditions, enabling searches for partially matching strings.

Examples of wildcards are listed below

% ·· Matches any number of characters including zero

_ ··· Matches a single character

Reference

Online transaction processing

"Online transaction processing" is a process in which a client connected to a network sends a processing request to a server, and the server performs the task accordingly and returns the results to the client. Usually, there are many processes involved with updating the database (including adding and deleting data), and if processing is interrupted, inconsistency in the data will result. For this reason, reliability is required.

9-3-4 Transaction processing

When manipulating a database, it is necessary to maintain database consistency using exclusive control, recovery functionality, etc. to handle referencing and updates to the data by multiple users.

1 Exclusive control

"Exclusive control" is a function that temporarily prevents data writing on the part of one user, when two are simultaneously attempting to update the same data in order to prevent inconsistencies from arising within the database. To restrict access, the database is **"locked."** The consistency of the data can be maintained by restricting access.

(1)Lock

By **"locking"** the database, users can be prevented from using data that is being updated or referenced by another user. There is an **"exclusive lock,"** where both updating and referencing are locked, and a **"shared lock (read lock),"** where only updating is locked.

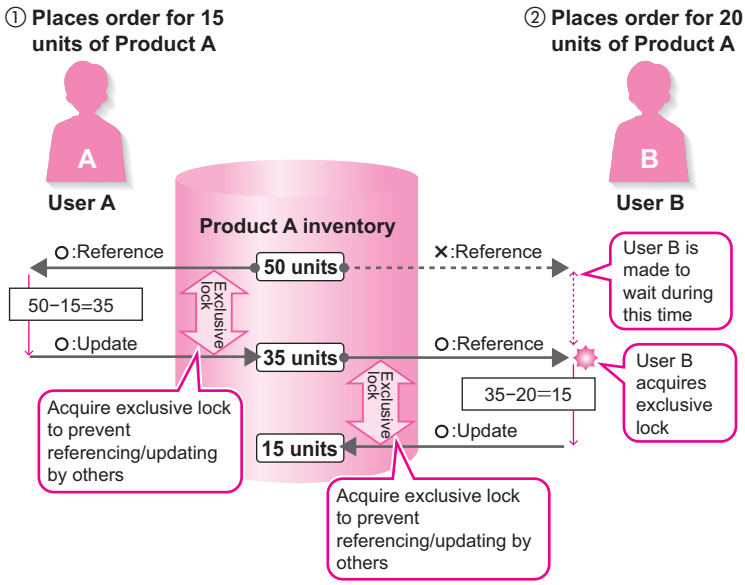
In general, when performing an update process (insert, update, or delete), the database management system automatically applies an exclusive lock. When performing a reference process, the program can specify whether to apply a shared lock.

[External data usage and lock status]

	Exclusive lock	Shared lock
Update	×	×
Reference	×	○
Delete	×	×
Exclusive lock by other program	×	×
Shared lock by other program	×	○

Example

A store has 50 units of Product A in inventory and two people order Product A simultaneously, reducing the inventory



(2)Transaction

A **"transaction"** is a set of operations that should be completed as one unit. For example, the process of **"placing an order for 15 units of Product A"** is a transaction.

Transactions are either accepted and completely processed, or rejected and not processed at all. If a transaction is completed successfully, the database is updated. However, if a transaction is interrupted and gets aborted, the database is not updated. This system maintains database consistency.

❷ Backups in the event of failure

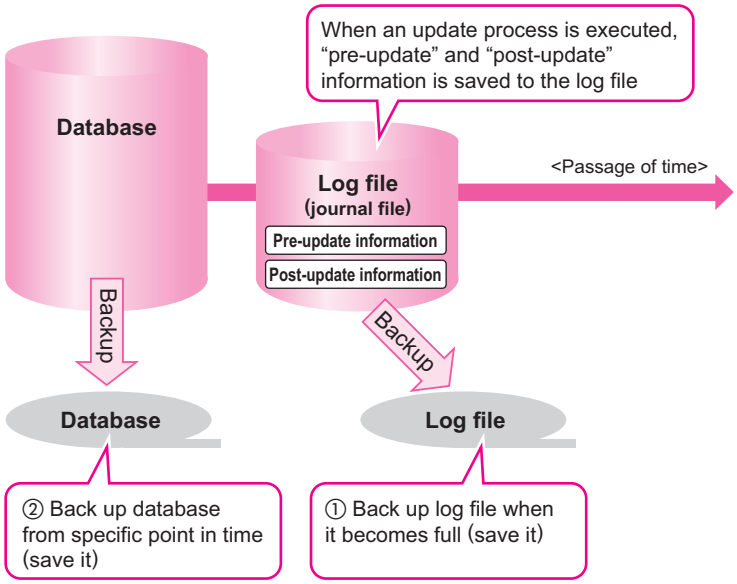
The database management system automatically writes updated information to a **"log file"** when an update process is executed on the database.

The database and log file should be backed up regularly just in case hardware failure occurs. If hardware failure does occur, a backup makes it possible to exchange the hardware and restore the database up to the point where the log file was last backed up.

Reference

Log file

A "log file" is a file that records activities that occur on a computer. It can be used to check who accessed the data on a server, when it was accessed, and what was done to it.



❸ Recovery process

The **"recovery process"** is the process of restoring the database to the state it was in when it was backed up or just before the trouble arose in the event of hardware or software failure.

There are two types of recovery processes, **"roll forward"** and **"roll back."**

●Roll forward

"Roll forward" describes the method of restoring a database to the state it was in when the log file was backed up by using the database backup, and reproducing the processes listed in the log file in the event of hardware failure or other issues.

●Roll back

"Roll back" describes the method of rewinding the data back to before the transaction, and starting again in the event an error occurs during a transaction.

9-4 Network

9-4-1 Network architecture

A **"network"** is a form of using multiple computers by connecting them with a cable.
A network provides the following functions that cannot be achieved by using a single standalone computer or personal computer.

•Sharing of resources

A network enables the sharing of software resources such as programs and data, and hardware resources such as storage devices and printers. Sharing data and other resources helps to improve the efficiency of work, and delivers other advantages such as cost reduction through sharing of hardware.

•Exchange of information

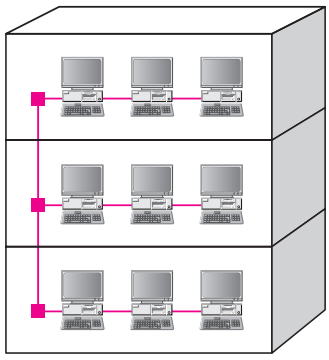
In addition to exchanging data, it is possible to exchange text and voice messages, and multimedia information such as images and video. By exchanging information, it is possible to use a variety of expressive means to communicate, even from a remote location.

1 Types of networks

The types of networks are summarized below.

(1)LAN (Local Area Network)

A **"LAN"** is a network that is used to exchange information within a relatively confined area such as a single building, site, plant, or school.



LAN

Reference

LAN

Abbreviation for "Local Area Network."

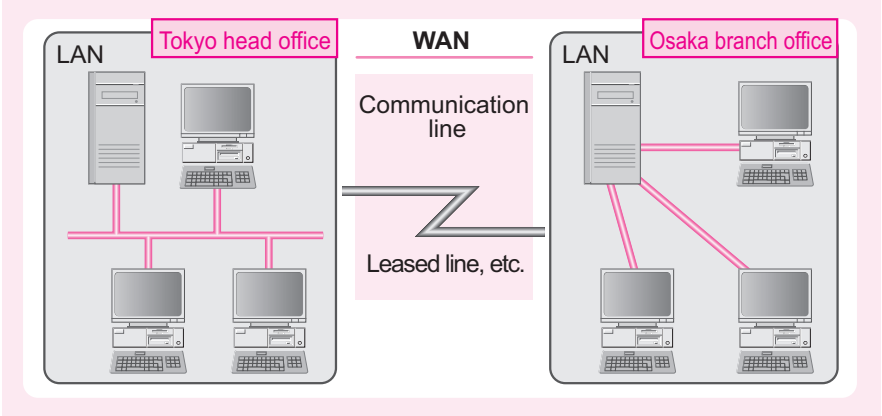
Reference

WAN

Abbreviation for "Wide Area Network."

(2)WAN (Wide Area Network)

A **"WAN"** is a network that connects computers from remote locations or connects LANs, using communication service (line services) that are provided by a telecommunications provider.



(3)Internet

Reference

Provider

Refer to "Chapter 9-4-3 3 Communication services."

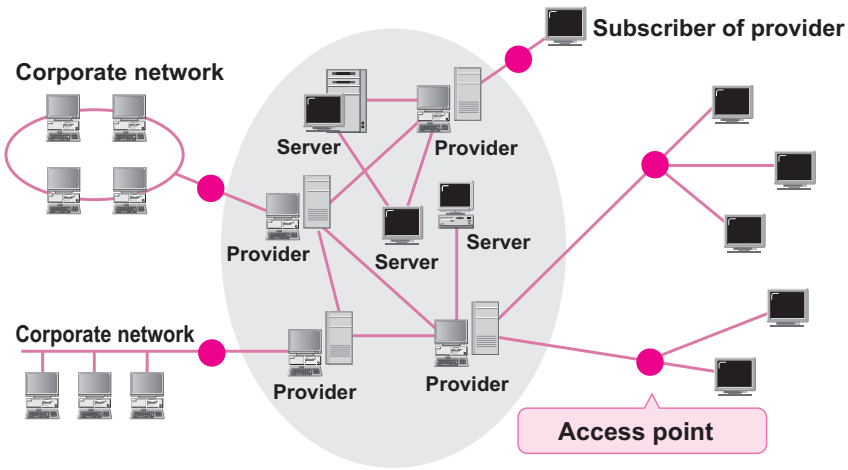
The **"Internet"** is a global system of interconnected networks comprising of LANs and WANs at corporations, and single computers in individual households.

By using the Internet, it is possible to view Web pages and exchange e-mail. In addition, it is possible to transmit information across the globe by creating and publishing a personal Web page.

Reference

Access point

An "access point" is a connection point that is provided for Internet users by a provider. Users connect to an access point by various means such as a leased line, ISDN line, or phone line.



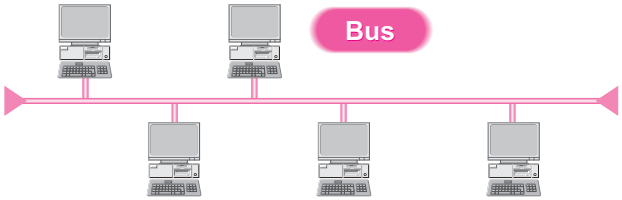
2 Network components

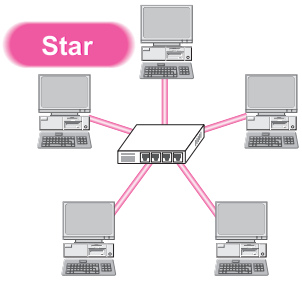
In order to build a network, it is necessary to understand the typical network architectures and components that comprise a network such as networking equipment and devices.

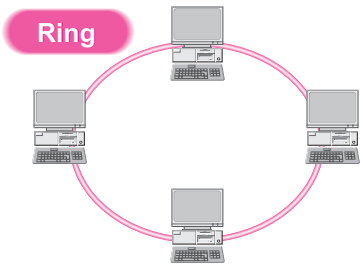
(1)LAN topologies

The type of connection for a LAN is called a **"topology."**
The three types of LAN topologies are summarized below.

Topology	Description	Advantages	Drawbacks
Bus	Computers and peripherals branch off from and connect to a single transmission path called a "bus."	A failure with a computer has few ramifications on the network.	Difficult to identify the point of failure. Cost of building this type of network is relatively high.
Star	Computers and peripherals radially branch out from and connect to line concentration devices such as hubs.	Easy to add and move computers.	A failure with a hub or other line concentration device stops the entire network.
Ring	Computers and peripherals are connected by a ring-shaped transmission path.	Easy to identify the point of failure.	A failure with even a single computer or transmission path stops the entire network. The cost of building this type of network is relatively high.







(2)LAN standards

There are various standards for LANs, each specifying a certain type of cable, topology, and access control. **"Ethernet"** is a typical LAN standard.

●Ethernet

"Ethernet" is the most popular international standard specification for LANs. **"Ethernet"** was jointly developed by DEC, Intel, and Xerox, and was later improved by the IEEE 802.3 Committee. It has now become an international standard specification.

Reference

Hub

Refer to "Chapter 9-4-1 2 (3) LAN components."

Reference

Transmission path

A "transmission path" is a path used for data communication. The width of the transmission path determines the amount of information that can be exchanged.

Reference

Segment

A “segment” is a unit of a LAN. It normally refers to the range of a single cable.

Reference

Fast Ethernet

“Fast Ethernet” is a high-speed Ethernet standard that delivers faster communication speeds of 100Mbps. There are a number of variations for this standard including 100BASE-TX that uses twisted pair cable, and 100BASE-FX that uses fiber optic cable.

Reference

Gigabit Ethernet

“Gigabit Ethernet” is a high-speed Ethernet standard that delivers faster communication speeds of one gigabit per second (1000Mbps). There are a number of variations for this standard including 1000BASE-T that uses twisted pair cable, and 1000BASE-LX that uses fiber optic cable.

Reference

Switch

A “switch” is a type of network device that connects networks, and refers to a line concentration device that houses twisted pair cable used for 10BASE-T and 100BASE-TX.

Reference

Backbone LAN

A “backbone LAN” is a LAN for connecting multiple LANs in which computers are directly connected, operating them together as a single network. A backbone LAN must be fast and reliable, and have a large capacity.

Reference

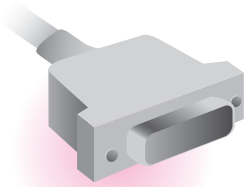
Types of cables

Refer to “Chapter 9-4-1 2 (3) LAN components.”

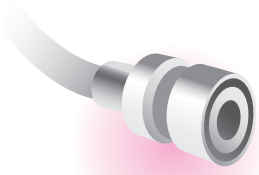
The types of Ethernet standards are summarized below.

Type	Standard	Transmission speed	Segment length	Topology	Type of cable	Connector	Application
Ethernet	10 BASE5	10Mbps	500m	Bus	Coaxial (10mm diameter)	AUI	Connect computers
	10 BASE2	10Mbps	185m	Bus	Light-weight coaxial (5mm diameter)	BNC	
	10 BASE-T	10Mbps	100m	Star	Twisted pair	RJ-45	
Fast Ethernet	100 BASE-TX	100Mbps	100m	Star	Twisted pair	RJ-45	Connect high-speed computers or backbone
	100 BASE-FX	100Mbps	2km	Star	Fiber optic	DSC	
Gigabit Ethernet	1000 BASE-T	1Gbps	100m	Star	Twisted pair	RJ-45	Backbone LAN
	1000 BASE-CX	1Gbps	25m	Star	Twisted pair	RJ-45	
	1000 BASE-LX	1Gbps	550m	Star	Multi-mode fiber optic	DSC	
		1Gbps	5km	Star	Single-mode fiber optic	DSC	
	1000 BASE-SX	1Gbps	550m	Star	Multi-mode fiber optic	DSC	

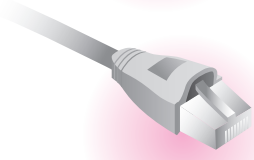
*1Gbps = 1000Mbps



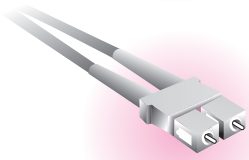
AUI



BNC



RJ-45



DSC

Recently, the demand for increased network capacity and speed are on the rise, driven by the need to connect more computers to networks, and handle more data such as voice and image data. In some cases, computers that run software which demand faster performance are directly connected using Fast Ethernet. In addition, backbone LANs are increasingly using Gigabit Ethernet that delivers speeds of one gigabit per second (1000Mbps) over conventional FDDI (Fiber Distributed Data Interface) networks that deliver speeds of 100Mbps.

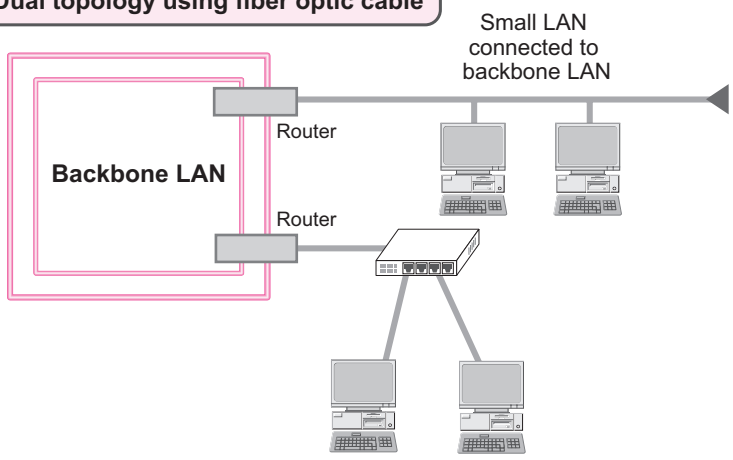
●Other LAN standards

Several types of LAN standards are summarized below.

Standard	Standards organization	Method of transmission	Transmission speed	Characteristics
FDDI	ANSI	Fiber optic cable	100Mbps	A dual ring topology that is capable of data communication, even if there is an interruption in a cable. (The network normally operates one of the two rings.)
Wireless LAN	IEEE 802.11 committee	Radio wave or infrared ray	1~11Mbps	Usable anywhere within the communication area, providing freedom of movement. Wireless LANs based on radio wave transmission are relatively unaffected by obstructing objects, with a transmission distance of around 100 meters. Wireless LANs based on infrared ray transmission cannot work around obstructing objects.

FDDI

Dual topology using fiber optic cable



Reference

FDDI

Abbreviation for "Fiber Distributed Data Interface."

Reference

ANSI

ANSI is a private organization whose aim is to unify and develop standards for the US industry. Many ANSI standards have become de facto global standards such as ASCII code, SCSI, and FDDI.
Abbreviation for "America National Standards Institute."

Reference

Precautions when installing wireless LANs

A wireless LAN enables communication within the range of radio waves, which requires security considerations beyond that of a cable-based LAN.

Authentication functions and communication encryption functions are often used to provide security.

●Wireless LAN

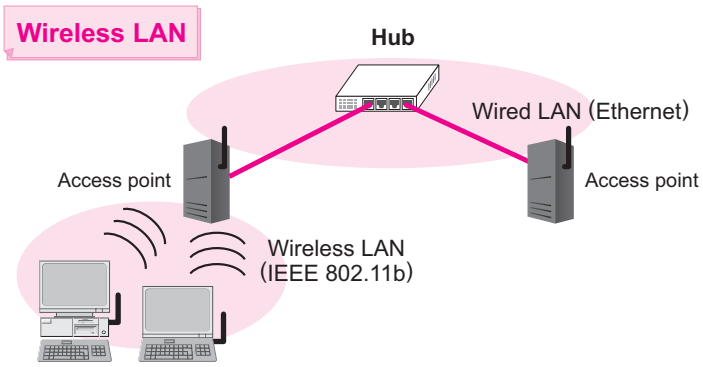
Wireless LAN is a technology for building networks using radio waves or infrared rays.

Since no cables are used, wireless LANs are used in places where the office layout is changed frequently, the wiring is complicated, or a tidier appearance is necessary.

Since there are several wireless LAN standards, care must be taken to match the supported standards. If the standards are not the same, communications will not be possible.

Several types of wireless LANs are summarized below.

Standard	Frequency band	Transmission rate	Characteristics
IEEE 802.11a	5.2GHz	54Mbps	Fast data rate. Uses higher frequencies and is sometimes affected by obstructing objects, but is resistant to noise as it uses a frequency that is not usually shared with other electronic equipment.
IEEE 802.11g	2.4GHz	54Mbps	Fast data rate. Compatible with 802.11b. Low frequency band tends to be unaffected by obstructing objects. However, communication quality is inferior to 802.11a, as it uses a frequency that is often shared with other electronic equipment.
IEEE 802.11b		11Mbps	Technology is more affordable than high-speed standards. Low frequency band tends to be unaffected by obstructing objects. However, communication quality is inferior to 802.11a, as it uses a frequency that is often shared with other electronic equipment.



(3)LAN components

The network equipment required to build a LAN are summarized below.

Equipment	Characteristics
LAN board	An expansion board for connecting a personal computer to a LAN. Also referred to as a "LAN adapter" or "NIC (Network Interface Card)." The LAN and personal computer must support the same standard.
Transceiver	A piece of equipment used to connect the LAN board installed on a personal computer to a coaxial cable for LANs that support the 10BASE5 standard. The transceiver provides functions such as sending and receiving between the personal computer and coaxial cable, and transmitting collision detection to the personal computer.
Hub	A line concentration device used for LANs with a star topology. Many hubs provide a repeater function. These are also called a "repeater hub."
Cable	Provides a connection for computers and equipment that connect to a LAN.

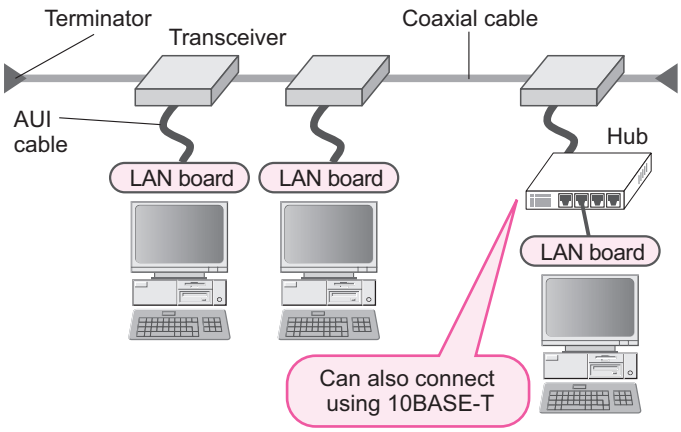
●Types of cables

Cables are required in order to connect computers and equipment that connect to a LAN.

Several types of cables are summarized below.

Cable	Characteristics
Coaxial cable	Comprised of a copper core surrounded by an insulating layer, which is in turn wrapped in a copper layer woven from fine copper wire. The cable is resistant to external noise. The diameter of the cable ranges from 10mm standard coaxial cable to 5mm thin coaxial cable.
Twisted pair cable	Comprised of several pairs of wires with copper cores. The cable is thin and flexible, which makes it easy to handle.
Fiber optic cable	Comprised of quartz glass or plastic fibers, which makes the cable thin and lightweight. Can transmit signals with almost no deterioration or attenuation of data, and is not affected by electromagnetic waves. Uses light to transmit data instead of electrical signals. Supports a wide range of transmission speeds from 10Mbps to 1000Mpbs.

10BASE 5



Reference

NIC

Abbreviation for "Network Interface Card."

Reference

Crossover cable

A twisted pair "crossover cable" is a cable that contains signal wires for input and output which cross over inside.

Reference

AUI cable

An "AUI cable," also called a "transceiver cable," provides a connection between a transceiver and LAN board or hub.

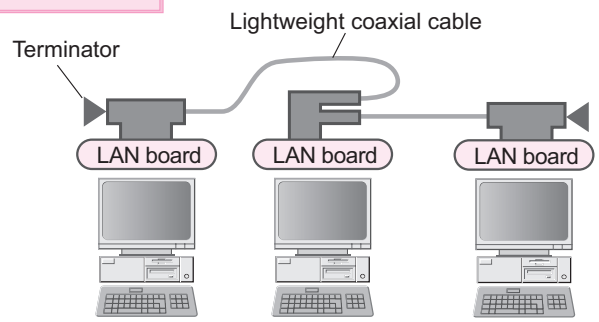
Abbreviation for "Attachment Unit Interface."

Reference

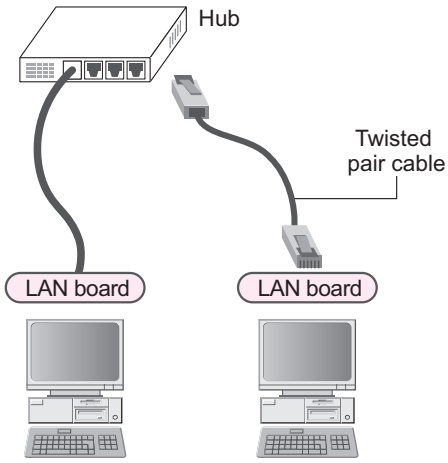
LAN analyzer

A “LAN analyzer” is a piece of software or hardware that monitors the packets (data) that are carried over a LAN, and analyzes the traffic (volume of data).

10BASE 2



10BASE-T



●Relay device

Various types of relay devices are used to expand a network.
The main types of relay devices are summarized below.

Device	Characteristics
Repeater	A device that amplifies an electrical signal carried over a cable to extend the transmission distance. Connects the first layer (physical layer) in the OSI model.
Bridge (bus)	A device that connects multiple LANs. The bridge remembers the MAC address for the LAN board in each computer, and can be configured to reduce traffic (data over the network) by not carrying data that is unnecessary to the LAN and unrelated to communications. Connects the second layer (data link layer) in the OSI model.
Switching hub (star)	A hub that provides functions for transferring packets only to LAN ports that have a destination MAC address. To provide this function, the switching hub has the ability learn the MAC address for each LAN port. Unlike a repeater hub, there are no limitations on the number of intermediary hubs that can be used.

Reference

MAC address

A “MAC address” is a 48-bit number that is assigned to a LAN board at the time of manufacturing. MAC address is assigned in order to identify each computer within the LAN.

Reference

Default gateway

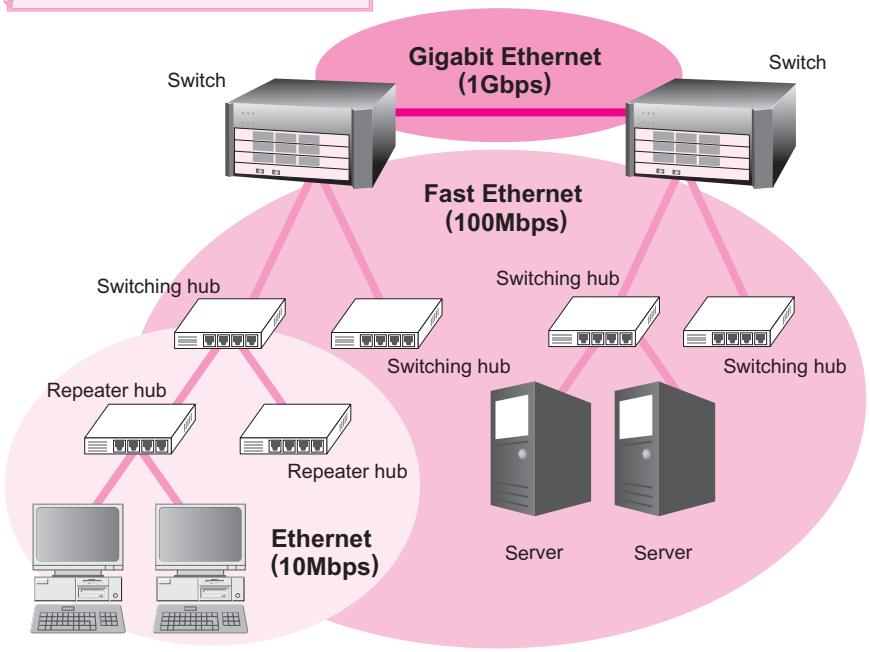
A “default gateway” is a piece of equipment such as a computer or router that is used when accessing a computer located outside the network. The equipment acts as a gateway to enable communications.

Reference

OSI

Refer to “Chapter 9-4-2 Communications protocols.”

LAN construction example



*Circles indicate the area of the transmission speed.

(4)Network communication lines

The types of equipment needed to perform data communication over a communication line are summarized below.

Type of communication line	Equipment needed	Role of equipment
Analog line	Modem (Modulation and demodulation device)	Provide conversion of digital signals and analog signals.
ISDN	DSU (Line terminating device)	Provide conversion for digital signal formats from computers and digital signal formats over the network, and a terminal connection for the digital line.
	TA (Terminal Adapter)	Provide conversion for ISDN digital signals and other signals such as analog signals. Many terminal adapters have a built-in DSU.
	Dial-up router	A router that is equipped with TA, DSU, or hub functions. Generally used to provide an Internet connection using an ISDN line for multiple computers on a LAN.
ADSL	ADSL modem	Provides conversion of ADSL analog signals and digital signals. The connection port on the computer can use an Ethernet or USB interface.
	Splitter	Separates the bandwidth used for voice signals and data signals.
FTTH	Media converter	Provides conversion for optical signals and electric signals.

Reference

DSU

Abbreviation for “Digital Service Unit.”

Reference

TA

Abbreviation for “Terminal Adapter.”

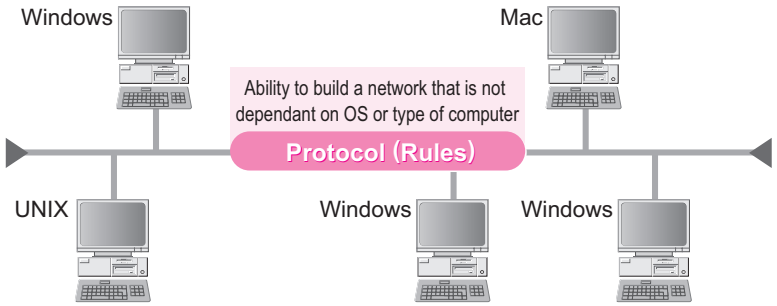
Reference

PBX

“PBX” is a piece of equipment that provides a private telephone exchange for extension phone use. The PBX connects to a phone line to enable a corporation or other organization to build an extension phone network within a restricted area.
Abbreviation for “Private Branch eXchange.”

9-4-2 Communications protocols

A **"protocol"** is a set of rules for data communication between computers over a network. In order to exchange data between computers, it is necessary to first decide on a mutual protocol.



1 OSI model

The **"OSI (Open Systems Interconnection) model"** is a protocol reference model and international standard. The OSI model was mainly developed by the ISO and ITU. It can be used as a starting point for developing a protocol that enables communications between different systems and different types of computers.

The OSI model divides the many protocols necessary for communications into functional layers.

The OSI model is comprised of the following seven layers.

Layer		Description
Layer 7	Application layer	Provides communication services such as file transfer and e-mail.
Layer 6	Presentation layer	Provides conversion into a form that is acceptable for data communication, and conversion into a form that the application layer can accept.
Layer 5	Session layer	Establishes and terminates communications.
Layer 4	Transport layer	Ensures reliable communications including retransmission in the event of communication errors.
Layer 3	Network layer	Transfers data between computers or relays data across multiple networks.
Layer 2	Data link layer	Sends data between adjacent computers.
Layer 1	Physical layer	Provides conversion of data into electrical signals and transmits the electrical signals.

Reference

OSI

Abbreviation for "Open Systems Interconnection."

Reference

ITU

The ITU develops international standards in the field of telecommunications for data and other communications. Abbreviation for "International Telecommunication Union."

❷ TCP/IP (Transmission Control Protocol/Internet Protocol)

"TCP/IP" is a set of protocols for data communication over the Internet, centering around the TCP and IP.
TCP/IP became a standard protocol with the spread of the Internet, and is often referenced today in describing the structure of the OSI model.

OSI model		TCP/IP model	Main protocols
Layer 7	Application layer	Application layer	SMTP, POP3, HTTP, FTP, Telnet, SNMP
Layer 6	Presentation layer		
Layer 5	Session layer		
Layer 4	Transport layer	Transport layer	TCP, UDP
Layer 3	Network layer	Internet layer	IP
Layer 2	Data link layer	Network interface layer	CSMA/CD, PPP Twisted pair, coaxial, fiber optic
Layer 1	Physical layer		

SMTP : Sends or transfers e-mail to a mail server.
POP3 : Retrieves e-mail from a mail server.
HTTP : Transfers files that are marked in HTML.
FTP : Transfers files.
Telnet : Provides remote operation of computers over a network.
SNMP : Manages communications equipment that is connected to a network over the network.
TCP : Provides reliable end-to-end data transfer services.
UDP : Provides high-speed data transfer services, but end-to-end does not guarantee reliability.
IP : Provides routing functions.
CSMA/CD : Monitors the usage of communication paths, and provides data transfer by detecting open transmission paths.
PPP : Connects computers to a network over a phone line. Frequently used for dial-up connections.

Reference

SMTP

Abbreviation for "Simple Mail Transfer Protocol."

Reference

POP3

Abbreviation for "Post Office Protocol version 3."

Reference

HTTP

Abbreviation for "HyperText Transfer Protocol."

Reference

FTP

Abbreviation for "File Transfer Protocol."

Reference

SNMP

Abbreviation for "Simple Network Management Protocol."

Reference

TCP

Abbreviation for "Transmission Control Protocol."

Reference

UDP

Abbreviation for "User Datagram Protocol."

Reference

IP

Abbreviation for "Internet Protocol."

Reference

CSMA/CD

Abbreviation for "Carrier Sense Multiple Access with Collision Detection."

Reference

PPP

Abbreviation for "Point-to-Point Protocol."

Reference

HTTPS

"HTTPS" is a protocol that combines HTTP with data encryption functions based on SSL.
Abbreviation for "HyperText Transfer Protocol Secure."

Reference

End-to-end

"End-to-end" refers to connectivity between the computers that engage in the final communications.

(1)TCP

"TCP" is a protocol that corresponds to the transport layer (Layer 4) in the OSI model. TCP provides reliable end-to-end communications.
It is equipped with the following functions to accomplish this role.

- **Divides and assembles data into packets.**
- **Assigns a number (sequence number) to packets, indicating the sequence in which the packets were divided.**
- **Uses numbers (port numbers) to identify the application software that supports the data.**

Port Number	Protocol
20, 21	FTP
23	Telnet
25	SMTP
80	HTTP

(2)IP

"IP" is a protocol that corresponds to the network layer (Layer 3) in the OSI model. Common functions of IP are **"addressing"** and **"routing."**

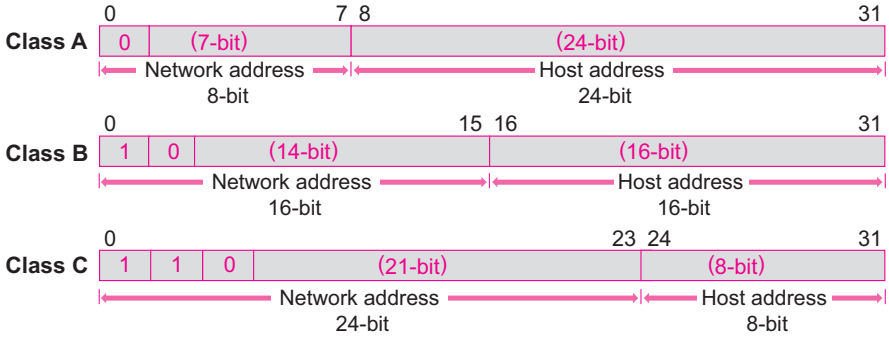
●Addressing

IP uses a number called an **"IP address"** to identify the computer connected to a network. An IP address is a 32-bit number, and is divided into a **"network address"** used to distinguish between multiple networks, and a **"host address"** to distinguish computers within a network.

	Network address		Host address	
IP address representation	160.	168.	1.	25
Binary representation	10100000	10101000	00000001	00011001

[IP address classes]

According to the scale of the network, IP addresses are divided into Class A, Class B, and Class C. The structures of Classes A to C are shown below.



Reference

IPv6

"IPv6" is an Internet protocol that provides expanded functionality over the current Internet protocol (IPv4) used.
IPv6 expands the manageable address space from 32 bits to 128 bits to address the shortage of available IP addresses caused by the rapid spread of the Internet.
Other characteristics include faster routing, plug-and-play functionality, security functions, multimedia support, and flexibility and expandability of functions.
Abbreviation for "Internet Protocol version 6."

[Number of network addresses and host addresses supported]

Class	Network scale	No. of network addresses	No. of host addresses
A	Large	$2^7 - 2$ = 126	$2^{24} - 2$ = approx. 16.77 million
B	Medium	$2^{14} - 2$ = approx. 160,000	$2^{16} - 2$ = approx. 650,000
C	Small	$2^{21} - 2$ = approx. 2.09 million	$2^8 - 2$ = 254

*For host addresses, "0" and "1" are always reserved for special purposes. Therefore the number of addresses is $2^n - 2$ (where "n" is the number of bits).
For network addresses, "0" and "1" are always reserved for special purposes on RFC 950 compliant networks. Therefore the number of addresses is $2^n - 2$ (where "n" is the number of bits). On RFC 1812 compliant networks, "0" and "1" are always usable as a valid subnet. Therefore there is no need to subtract two.

●Global IP address and private IP address

A **"global IP address"** is an IP address assigned to a computer that connects to the Internet. In order to connect to the Internet, it is necessary to obtain a global IP address assigned by **"JPNIC."**

A **"private IP address"** is an IP address assigned to a computer that only connects to an individual network such as a corporate network. A private IP address cannot be used to directly connect to the Internet.

●Routing

A **"router"** is a device that connects multiple LANs and WANs to transfer data between computers using the best path of transmission. A router corresponds to the network layer (Layer 3) in the OSI model.

The main function of a router is to perform **"routing."** Routing is the process of transferring data using the best path of transmission so that the data reaches the destination computer. Routers are positioned between computers engaged in communications and each one decides the next router to send the data to, and relays the data. To decide on the next router, the router uses the destination IP address in the IP packet and searches for it in the routing table within the router.

Routing is also referred to as **"path control"** and **"path selection."**

Reference

RFC

An "RFC" is a document prepared by the IETF (Internet Engineering Task Force) that describes technical information, specifications, and operating rules concerning the Internet.
IETF is an organization that develops standards for Internet technologies.
Abbreviation for "Request for Comments."

Reference

JPNIC

The "JPNIC" is an organization that administers the NIC in Japan. It oversees all administration for the assignment of IP address and domain names in Japan. In order to make a corporate mail server available or publish a Web server over the Internet, it is necessary to apply for and acquire an IP address and domain name from JPNIC.
Abbreviation for "Japan Network Information Center."

Reference

NIC

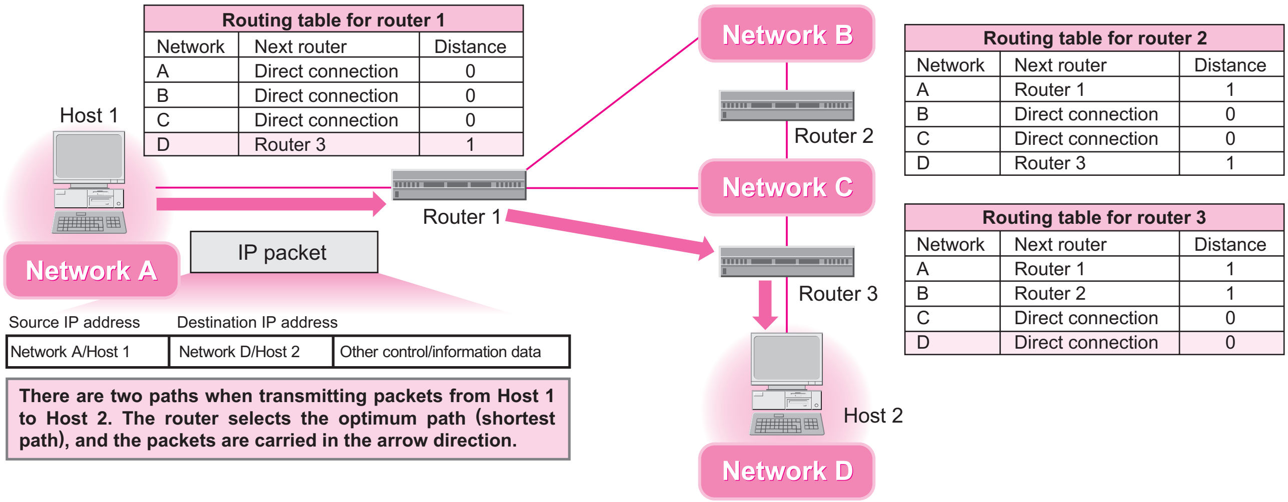
The "NIC" is based in the United States, and is the central governing body for network information. It oversees all administration of IP addresses and supplies IP addresses.
Abbreviation for "Network Information Center."

Reference

Routing table

A "routing table" lists routing information for the send destination of packets that are managed by the router. Specifically, a router stores a routing table that corresponds with the destination for received packets, and the networks or router IP addresses through which the packets are sent to the destination. Routing tables can be generated and managed via "static routing," in which the administrator of the router manually configures each routing table, and "dynamic routing," in which routers automatically configure routing tables by exchanging information between routers.

Router



Routing table for router 1

Network	Next router	Distance
A	Direct connection	0
B	Direct connection	0
C	Direct connection	0
D	Router 3	1

Routing table for router 2

Network	Next router	Distance
A	Router 1	1
B	Direct connection	0
C	Direct connection	0
D	Router 3	1

Routing table for router 3

Network	Next router	Distance
A	Router 1	1
B	Router 2	1
C	Direct connection	0
D	Direct connection	0

There are two paths when transmitting packets from Host 1 to Host 2. The router selects the optimum path (shortest path), and the packets are carried in the arrow direction.

Reference

IMAP4

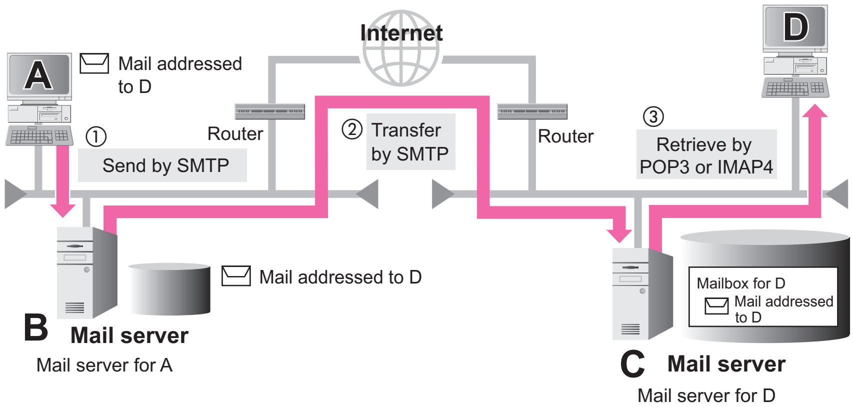
Abbreviation for "Internet Message Access Protocol version 4."

❸ Protocols used for e-mail

The protocols used for e-mail are summarized below.

Protocol	Description
SMTP	A protocol for sending e-mail. Used when sending e-mail between mail servers, or from a mail client to a mail server.
POP3	A protocol for retrieving e-mail. Retrieves all newly arrived e-mail that has been stored on the mail server and is addressed to the user.
IMAP4	A protocol for retrieving e-mail. Can selectively retrieve e-mail that is stored on the mail server.

Example
Protocol for sending e-mail from A to D



●Other protocols used for e-mail

Other protocols that extend the data formats or provide added security functions are summarized below.

Protocol	Description
MIME	A protocol that extends the data formats for sending and receiving e-mail, in addition to the text format. Using MIME, it is possible to send and receive multimedia files such as static images, video, and audio media as attachments.
S/MIME	A protocol that extends MIME with additional security functions (encryption functions). Can be used to prevent interception, spoofing, and falsification of e-mail.
APOP	Protocol that encrypts passwords. Can be used to encrypt passwords sent to providers when retrieving e-mail.

Reference

MIME

Abbreviation for "Multipurpose Internet Mail Extensions."

Reference

S/MIME

Abbreviation for "Secure/Multipurpose Internet Mail Extensions."

Reference

APOP

Abbreviation for "Authenticated Post Office Protocol."

9-4-3 Network application

There are many kinds of services that can be used over the Internet. In order to utilize these services, it is necessary to understand the framework of the Internet.

1 Framework of the Internet

The Internet was born when the **"ARPANET (Advanced Research Projects Agency Network)"** was created as a distributed computer network by the United States Department of Defense in 1969. In the early 1970s, research institutes such as those at universities were connected to the network, and in 1991 the network was opened to commercial providers. The Internet has since spread at an explosive rate to become what it is today.

Computers from around the globe can mutually connect over the Internet through the use of protocols to exchange information.

Reference

ARPANET

Abbreviation for "Advanced Research Projects Agency NETwork."

(1)DNS

"DNS (Domain Name System)" is a framework for providing services to manage the one-to-one matching of IP addresses and domain names. When computers communicate to each other, IP addresses are used to find the other computer. However, since IP addresses are represented as numbers, they are difficult for people to use. A domain name is therefore used as a separate name for an IP address.

Reference

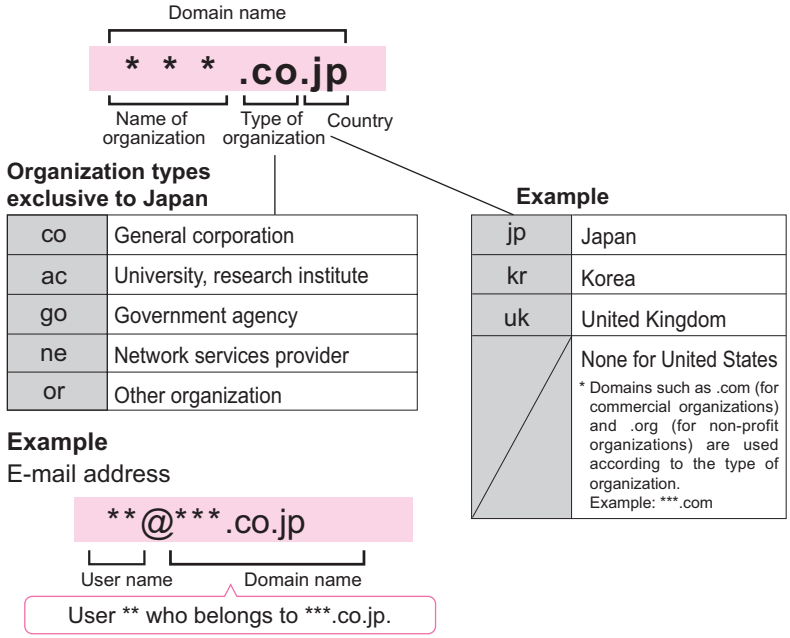
DNS

Abbreviation for "Domain Name System."

(2)Domain name

A **"domain name"** uses a combination of characters to represent an IP address, and is easier for people to understand. Domain names are generally used to access servers over the Internet.

Starting from the end, the domain name is divided into a **"TLD (Top-Level Domain)"** preceded by a **"SLD (Second-Level Domain)."** The domains are separated by a **". (Dot),"** with the highest level domain placed at the end of the domain name in descending order to the left.
The top-level domain is represented as a two-character country abbreviation. The second-level domain is an **"organization domain"** that describes the type of organization that holds the domain name. In Japan, it is customary to use the organization domain, but usage of third-level and lower domains depends on the country. A domain that is to the left of the second-level domain is called a **"sub-domain."** The front of the domain name is appended with WWW, or in the case of a large organization, it is appended with a character string that distinguishes the group or other sub-organization.

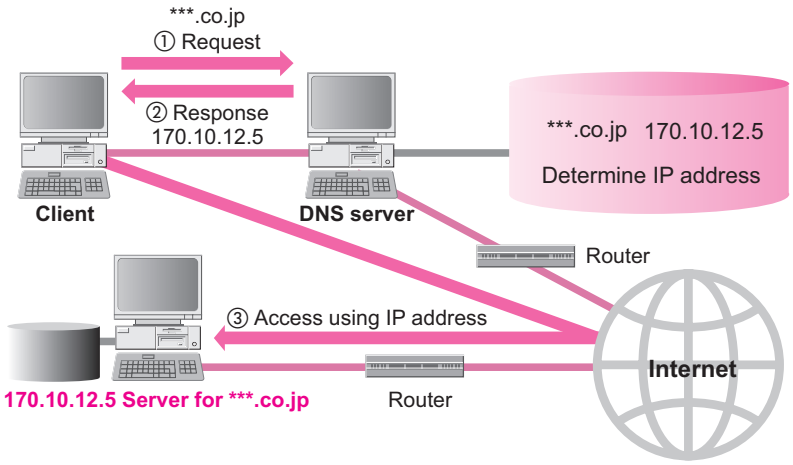


The new operating rules for JP domains that use a domain name ending with **"jp"** are referred to as the **"generic JP domain"** system. Under the previous system for JP domains, second-level domains that describe the type of organization (such as **"co"** or **"ne"**) were restricted to the organization types decided by JPNIC. Under the generic JP domain system, second-level domains are now available to general users and open to registration such as registering an organization name. In addition, where the previous system only allowed one organization to register one domain name in principle, the new system enables organizations to acquire any number of domain names. The generic JP domain system also opens up the use of domain names with Japanese characters, and the ability to transfer domain names.

(3)DNS server

A **"DNS server"** is a server with DNS functions. A DNS server provides services for translating domain name requests from clients into IP addresses.
DNS servers make it possible to view Web pages or send e-mail without the user having to know the IP address.

Example
Accessing ***.co.jp



❷ Internet services

A variety of services are provided over the Internet.
The main types of services provided over the Internet are summarized below.

Service name	Description	Protocol
WWW	A service for publishing or viewing information over the Internet. Can be used to publish and view static images, video, and audio in addition to text information (characters).	HTTP
E-mail	A service for exchanging messages. Enables the user to exchange messages with a specific person, similar to exchanging letters.	SMTP, POP3, IMAP4
FTP	A service for transferring files. Used to download and upload files.	FTP
Telnet	A server that enables remote operation of computers over a network.	Telnet
Netnews	An information sharing service. Users can subscribe to newsgroups to receive messages from group members, or send a message to all group members.	NNTP

❸ Communication services

An **"ISP (Internet Service Provider)**," also called a **"provider**," provides communication services for the Internet. Connection fees are collected from users and in return, various Internet services are provided.

Reference

Broadcast mail

"Broadcast mail" refers to the process of sending e-mail containing the same content to multiple e-mail addresses. When sending broadcast mail, e-mail addresses are entered into the "Cc" or "Bcc" address slots.

Cc: E-mail addresses of persons to receive mail are specified for reference. Addresses are visible to all recipients so that recipients can be made aware of who else the message has been sent to. Abbreviation for "Carbon Copy."

Bcc: Unlike Cc, e-mail addresses are hidden from recipients so that recipients do not know who else the message has been sent to. Abbreviation for "Blind Carbon Copy."

Reference

Mailing list

A "mailing list" is a system that can be used to communicate with multiple persons using e-mail. It is possible to send e-mail to all of the members registered to the mailing list simply by sending an e-mail to a specified address.

Reference

Mailbox

A "mailbox" is a virtual space that is used for temporarily storing incoming e-mail.
Usually, an upper limit is placed on the capacity of the mailbox.

Reference

NNTP

Abbreviation for "Network News Transfer Protocol."

Reference

ISP

Abbreviation for "Internet Service Provider."

Reference

Carrier

A "carrier" is a business operator who provides lines for connecting to the Internet.

Reference

Exchange line service

An "exchange line service" is a communication service that is capable of connecting to an unspecified host. The connection is established by dialing for every communications session, using a device called an exchanger. This service uses a telephone line.

Reference

Leased line service

A "leased line service" is a communication service that is permanently connected to the specified host that the user has subscribed to.

Reference

ISDN

Abbreviation for "Integrated Services Digital Network."

Reference

Packet switching

"Packet switching" is a method for data communication that sends data by dividing it into packets.

Reference

Packet

A "packet" is a unit of measurement for data transfer, which is derived by dividing data into blocks that do not exceed a fixed length.

Reference

IP phone

An "IP phone" is a telephone service that is provided by using the "IP (Internet Protocol)" over the Internet. Voice calling is accomplished by converting voice data into digital data, which is divided into packets and sent to the called party over an IP network.

(1)Types of communication services

The main types of communication services are summarized below.

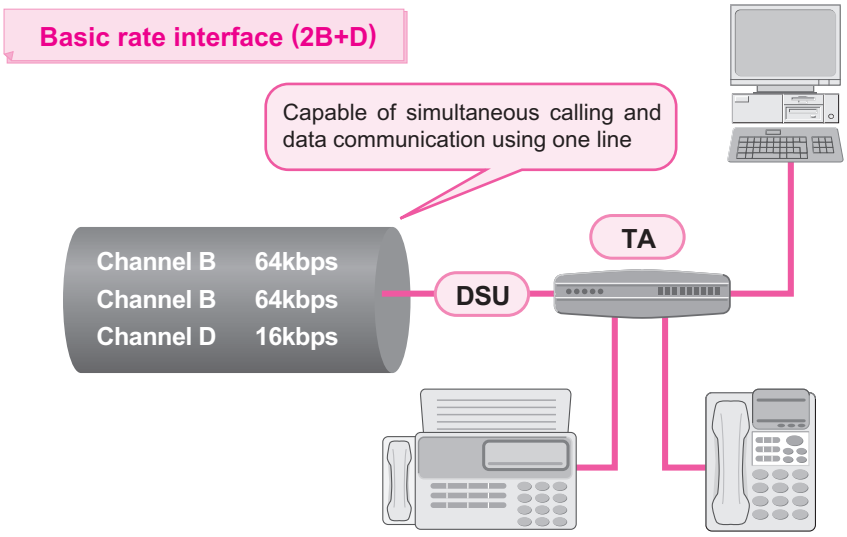
●Telephone line

A **"telephone line"** is a communication service whose main purpose is for voice communications using a common telephone line (analog line). The transmission speed is slow at a maximum speed of around 56kbps. Since a telephone line is an analog line, a **"modem"** is required to convert digital data into analog data, and connect to a computer that processes the digital data.

●ISDN (Integrated Services Digital Network) line

"ISDN" is a digital communication service that supports a wide variety of data communication including voice, image, and fax communications. Certain equipment is necessary in order to use ISDN such as a DSU, terminal adapter, and dial-up router.

A typical ISDN service is **"BRI (Basic Rate Interface),"** also called **"2B+D."** BRI is comprised of a pair of information channels (B channels) and one control channel (D channel) for each subscriber line. Each of the two information channels can be used respectively for data communication or voice communications, making it possible for one computer to use the Internet while simultaneously talking on the same line using telephone equipment. The control channel mainly sends control information such as the telephone number of the other communicating party. Data communication using packet switching can also be performed.



●ADSL (Asymmetric Digital Subscriber Line)

"ADSL" is an asymmetric service that is capable of high-speed data communication by taking advantage of the unused bandwidth of a telephone line (analog line). The service is asymmetric in that the upstream (computer to network) and downstream (network to computer) communication speeds are not equal. Upstream speeds range from around 512kpbs to 12Mpbs, while downstream speeds range from around 1Mpbs to 50Mpbs. This line service is particularly suited to activities that involve a high volume of download communications such as viewing Internet Web pages and downloading files.

●FTTH (Fiber To The Home) or optical communication

"FTTH" is a method of high-speed communications in which optical signals are carried over optical fibers. In order to use FTTH, it is necessary to install fiber optic lines inside the building that receives the service. FTTH has a maximum speed of one gigabit per second, making it the fastest communication service among the methods of communication that are available to an individual user.

●CATV (Cable television)

"CATV" is a data communication service that takes advantage of the unused bandwidth of a cable television line used to send video. Depending on the cable television company that is used, the service can provide high-speed communications of around several tens of megabits per second.

●ATM (Asynchronous Transfer Mode)

"ATM" is a method of communication for transferring cells that are frames of a fixed length. It was originally developed as a communication technology for WANs to make it possible for a single network to carry various types of information such as voice calls, data communication, and video.

ATM is utilized in order to effectively use high-speed data lines such as fiber optic lines.

●Mobile communications

"Mobile communications" is a service for providing data communication by using a data communication card paired with a mobile terminal such as a laptop computer, PDA, mobile phone, or PHS handset. Since the service relies on wireless communications, it is possible to conduct data communication anywhere within the service range.

●Packet communications

"Packet communications" is a method of communication that sends and receives data by dividing data into small blocks of a fixed size. Dividing the data into small blocks enables multiple persons to share and effectively use a single communications line. It is widely used as it is not prone to problems such as line interruption.

Reference

Broadband

"Broadband" refers to a communication service that is capable of high-speed, large bandwidth communications such as ADSL and FTTH. The opposite of broadband is "narrowband," which refers to low-speed communication services provided over an analog line (telephone line).

Reference

ADSL

Abbreviation for "Asymmetric Digital Subscriber Line."

Reference

FTTH

Abbreviation for "Fiber To The Home."

(2)Billing methods

"Billing" refers to the process of charging fees for the use of services. There are various billing methods including flat, metered, and base plus metered.

Billing method	Fee structure
Flat	Usage fees are always billed at a flat rate regardless of the length of usage, such a "flat 1,000 yen monthly fee."
Metered	Billed according to the length of usage such as "10 yen per three minutes."
Base plus metered	Billed at a base fee plus additional metered charges, with the additional charges covering usage that exceeds the amount covered by the base fee.
Cap	Capped at a maximum fee such as "10 yen per three minutes up to one hour, not over 1,000 yen per month regardless of usage."

●Calculation of transmission time/communications fee

The **"transmission time"** refers to the time required to transmit data. The following formula can be used to calculate the transmission time, and the communications fee for the transmission time.

Formula for calculating transmission time

Transmitted data ÷ (Line transmission speed × Transmission efficiency)

Example 1

Approximately how many minutes are required to transmit data under the following conditions?

Transmission data : 2000 × 1,500 pixel JPEG image, 16.77 million colors, compressed to one-tenth size
Line speed : 33.6kbps modem
Transmission efficiency : 60%

① Calculation of transmission data volume

$$\underbrace{2000 \text{ pixels} \times 1500 \text{ pixels}}_{\text{(Total pixels)}} \times \underbrace{24 \text{ bits per dot}}_{\text{(16.77 million colors is } 2^{24}\text{)}} \times \underbrace{\frac{1}{10}}_{\text{(Compression rate)}}$$

= 7,200,000 bits

② Calculation of transmission time

$$\underbrace{7{,}200{,}000 \text{ bits}}_{\text{(Transmission data volume)}} \div \underbrace{(33{,}600 \text{ bits per second}}_{\text{(Line transmission speed)}} \times \underbrace{60\%)}_{\text{(Transmission efficiency)}}$$

≒ 357 seconds ≒ 6 minutes

Therefore, approximately six minutes are needed to transmit the data.

Reference

Transmission speed

The "transmission speed" indicates the amount of data that can be transferred within a specific time. It is expressed in units such as "bps (bits per second)" or "B/s," which is the amount of data that can be transmitted in one second.

Reference

Transmission efficiency

The "transmission efficiency" is the percentage of actual data that is contained within all the transmitted data. Due to the inclusion of other data such as control codes, the transmission efficiency normally ranges from 60 to 80%.

Example 2

What are the phone charges for downloading a file from the Internet using a mobile phone under the following conditions? Please ignore the time required for specifying the file, and for connecting and disconnecting the line. Also, assume that only mobile phone fees are incurred for using the Internet connection service provided by the mobile phone carrier.

Mobile phone fee	: 30 yen per 30 seconds
Communication speed	: 9,600 bits per second
Effective communication speed	: 80% of communication speed
Size of download file	: 1.2 megabytes (1 byte = 8 bits)

① Calculation of transmission time

1.2 megabytes × 8 bits ÷ (9,600 bits per second × 80%)
(Transmission data volume) (Line transmission speed) (Transmission efficiency)

= 9,600,000 bits ÷ 7,680 bits per second

= 1,250 seconds

② Calculation of phone fee

1,250 seconds ÷ 30 seconds = 41.666 ⋯ 30-second units transmitted 42 times

42 times × 30 yen per 30 seconds = 1,260 yen

Therefore, the phone fee for downloading the file is 1,260 yen.

9-5 Security

9-5-1 Information assets and information security

Corporations and other organizations handle a wide variety of information such as personal information and confidential information, and also share information using computers. **"Information"** of this type is an important **"asset,"** regardless of whether it is from the perspective of a corporation, organization, or educational institution. These information assets must be strictly managed.

1 Information assets

"Information assets" refers to assets whose value should be protected such as data, software, computers, and network equipment. The adoption of computers and spread of the Internet has rapidly increased the use of information by corporations and other organizations.

When a corporation has customer information that only it should use and the information is leaked to the outside, it can hurt the competitiveness of the corporation and ultimately threaten its very existence.

In addition, personal information such as customer information must be protected from the standpoint of privacy, while leakage of such information is certain to damage the credibility of the organization.

For these reason, organizations must treat "information" as "assets."

Information assets can be broadly categorized into **"tangible assets"** and **"intangible assets."**

Examples of tangible assets

- Data printed on paper
- Hardware such as servers and computers
- Network equipment

Examples of intangible assets

- Data such as customer information, personal information, sales information, and information concerning intellectual property
- Software such as operating systems and applications
- Knowledge and experience of people

❷ Classification of information

Information that is handled by an organization can be broadly categorized into **"published information"** and **"unpublished information."**
Published information refers to information that has been made available to the public such as product catalogs and information on Web pages, and information that can be published without issue.
Unpublished information refers to confidential information that is not in the interest of the organization to publish such as information about new product development, and personal information such as customer information and address information.
In handling information, it is necessary to rank the importance of the information, taking into account the value of the information and the extent to which people will use the information. It is also important to decide the administrator of the information and how the information will be managed.
After determining if information is published information or unpublished information, it is necessary to take adequate precautions for the handling of unpublished information in particular.
Information can be ranked as follows.

	Rank of importance	Content of information
Unpublished	A: Confidential information	Product cost sheets, human resources information, customer information
	B: Information for internal use only	Marketing information, sales information
Published	C: Published information	Information published on the Web, product catalogs

❸ Threats and vulnerabilities

Information systems and the Internet are widely used today by corporations and other organizations, making it possible for anyone to quickly and easily use information. At the same time, there is seemingly no end to incidents involving virus infections or unauthorized access of information systems. It is important to grasp the various risks involved, and institute appropriate measures to protect information assets from such risks and ensure safe use of information assets.

(1)Types and characteristics of human threats

In the field of security, **"social engineering"** refers to the act of manipulating people to obtain important information through physical and personal means, and use it for fraudulent purposes. Anyone can easily use information for fraudulent purposes by preying on the psychological vulnerabilities of people, even without possessing technical knowledge. For this reason, due caution is necessary.
The typical methods of social engineering are summarized below.

●Spoofing

"Spoofing" is a technique that is used to masquerade as someone such as a superior, person from an information systems department, or customer. Once the person has asked and obtained information for the purpose of gaining unauthorized access, the person masquerades as the normal user using the stolen ID or password, and proceeds to use a computer for fraudulent purposes.

●Intrusion

"Intrusion" is the process of trespassing into a building or site by using items such as an ID card that have been found or stolen.

●Trash scouring

"Trash scouring" is the process of masquerading as cleaning staff in order to dig through trash and gather information such as customer information, human resources information, and product development information.

●Peeping

"Peeping" is the act of looking at someone's keyboard while they are entering a password. It can also mean looking at the computer display of another person over their shoulder, or looking at memos or notes on the desk of a person while that person is away.

●Theft, leakage, and loss of information

"Theft" of information refers to the act of intruding on a system without authorization to remove important and confidential information from within the system. **"Loss"** of important information can occur if a person removes a notebook used for work from the workplace and misplaces it.
Theft or loss of confidential information can result in its **"leakage"** to third parties.

●Damage to data

Damage to data can occur if storage media or hard disks on which data is stored are damaged, or if important documents are accidentally shredded to render the data unusable.

●Cracking

"Cracking" is the act of intruding on a system without authorization to engage in illegal acts such as the destruction or falsification of information. A person who commits such an act is called a **"cracker."**

●Falsification of information

"Falsification of information" is the act of intruding on a system without authorization in order to rewrite data within a computer using an unauthorized means.

Reference

Information leakage from operational error

Sometimes important information can be erroneously leaked by internal employees due to errors in e-mail handling such as sending e-mail to the wrong recipients or attaching the wrong files.

(2)Types and characteristics of technical threats

Technical threats include attacks that are designed to create confusion among users, or overload an externally accessible server such as a Web server or mail server so that it stops providing services. The typical threats are summarized below.

●Computer viruses

A **"computer virus"** is a malicious program that is created for purposes such as intruding into a computer without the user's knowledge to destroy data within the computer, or to spread the virus to other computers. It poses the greatest threat upon usage of information systems and the Internet.

A computer virus usually has a life cycle of **"infection"**, **"dormancy"**, and **"appearance of symptoms."**

Infection occurs when the virus is copied to other programs

No symptoms appear until certain conditions are met

Causes the destruction of programs or data, or triggers abnormal computer operations

The types of computer viruses are summarized below.

[Type of virus by symptoms]

Type	Symptoms
Program destruction	Causes destruction to the OS as the basic software, or causes destruction to application software.
Data destruction	Causes destruction to data such as files on auxiliary storage devices.
Screen display destruction	Suddenly displays objects on the screen of the display such as pictures, graphics, or characters.
Specific date/time message output	Causes symptoms that lower the performance or cause the destruction of files, only when the computer is operated on a specific date/time.

[Type of virus by infection object]

Type	Symptoms
Boot sector virus	Infects the location that stores the programs that are executed on system launch. Infection is dependent on the OS and type of machine.
Program virus	Infects other programs during the program execution. Infection is dependent on the OS and type of machine.
Macro virus	Infects files that are created using applications such as word processing or spreadsheet software. Infection occurs when the file is opened. Infection is not dependent on the OS and type of machine as long as the macro framework is the same.

●Port scan

A **"port scan"** is the process of scanning a computer to look for open port numbers. If an open port number is found, it is exploited for intrusion purposes or to block services that use the open port number.

Reference

Malware

"Malware" broadly refers to software that has a malicious intent. Computer viruses are a common example of malware.

Reference

BOT

A "BOT" is a newer type of computer virus created for the purpose of using a computer for malicious purposes. Once a computer is infected with a BOT, a third party with a malicious intent can manipulate the computer and cause serious damage through acts of nuisance such as e-mail bombs and DoS (Denial-of-Service) attacks. The name comes from manipulating an infected computer as if it were a "robot."

Reference

Spyware

"Spyware" broadly refers to software that sends personal or other information from within a computer to the Internet. Users are often unaware that they have spyware installed on their computer, which can lead to serious damage.

Reference

Stealth virus

A "stealth virus" is a type of virus that attempts to conceal itself so that it is hard to find the infection.

Reference

Worm

A "worm" is a program that continues to replicate itself when an infected computer is connected to a network. The spread of damage depends on the network load.

Reference

Trojan horse

A "Trojan horse" is a program that masquerades as a utility or other useful program, but performs unauthorized processing when the program is executed. The unauthorized processing can include the destruction of data within the computer, or the automatic sending of keystroke information. As it does not self-replicate on infection, it is technically not a computer virus.

●Password crack

A **"password crack"** is the process of engaging in analysis to discover a user name and password, which a cracker requires in order to use a computer for an unauthorized purpose. One form of password cracking is a **"dictionary attack"** that involves analysis in combination with a file (dictionary file), which comprises a large list of descriptions of candidate user names and passwords. Another form of password cracking is a **"brute force attack**," which involves analysis in combination with a program that generates random character strings.

●Stepping stone

A **"stepping stone"** refers to the use of computer with weak security as a cloaked base for a cracker to attack a target system.

●Buffer overflow attack

A **"buffer overflow attack"** is an intentional attempt by a cracker to overflow the buffer on a computer by executing unauthorized processes. The attack is executed by sending data that exceeds the memory capacity (buffer) secured by a program operating on a computer.

●DoS attack

A **"DoS (Denial-of-Service) attack"** is an attempt to disable the functions of a server by overloading the server. In general, this method involves sending a large amount of packets that exceed the processing capacity of the server. A **"distributed denial-of-service (DDoS)"** attack is an attack that uses multiple computers to execute DoS attacks at the same time. The network congestion created by the attack can render the entire server unusable to general users.

Reference

DoS

Abbreviation for "Denial-of-Service."

●E-mail bomb

An **"e-mail bomb"** attack is an attempt to disable the functions of a mail server by sending a large amount of e-mail to overload a server. It is a type of DoS attack that is used to harass a specific user.

●Phishing

"Phishing" is the act of sending e-mail as if it were from an actual corporation or organization to obtain the personal credit information of the recipient such as credit card numbers, IDs, and passwords.

Reference

File exchange software

"File exchange software" refers to software that enables the exchange of files between computers on a network. When a file is published on a computer that has been installed with file exchange software, users on other computers can download that file. Careless use of file exchange software can lead to a serious breach of information leakage.

●Cross-site scripting

"Cross-site scripting" is a type of security hole vulnerability in software. The vulnerability can be exploited to steal personal information or destroy files on a computer when a user views a malicious website containing embedded code. The damage occurs when the website is posted to a bulletin board or online forum.

Reference

Security hole

A "security hole" refers to a security vulnerability in software.

(3)Types and characteristics of physical threats

Physical threats such as natural disasters, destruction, and sabotage can prevent access to information or lead to the destruction of information, which in turn can interfere with the execution of work or provision of services.

●Natural disasters

Natural disasters such as earthquakes, fire, and flooding can cause the destruction of computers or information. Unlike threats from social engineering, it is difficult to control threats from natural disasters. Measures that include appropriate response after a threat has materialized must be formulated.

●Destruction and sabotage

Deletion of data within a computer, destruction of actual storage media, and spread of malicious code or programs through unauthorized access to computers can interfere with work.

9-5-2 Information security management

"Risk management" refers to the process of ascertaining and analyzing risks, and assessing the risks from the standpoint of the frequency of occurrence and extent of impact, in order to implement certain measures according to the type of risk. It is also important to formulate measures to minimize the damage, if the risk actually materializes. Information security management and personal information protection are types of risk management.

1 ISMS (Information Security Management System)

"ISMS" is a unified framework for an organization to improve the level of information security by implementing necessary information security measures based on risk analysis/assessment.

(1)Risk management

"Risk management" is a method for identifying where and how risks exist in using information systems, and measuring the extent of losses and impact if the identified risks materialize. The order of priority is also determined for foreseeable risks, starting with risks that have the greatest probability of materializing and incur the greatest losses.

Reference

ISMS conformity assessment system

An ISMS conformity assessment system is a system for assessment that is conducted by a third party examination and registration organization to determine conformance with international conformity standards.

Abbreviation for "Information Security Management System."

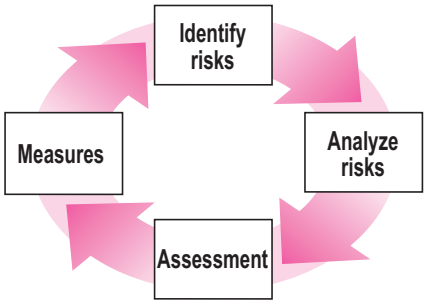
"Risk assessment" is implemented in the following order.

Identify	Identify where and how risks exist.
Analyze	Analyze the extent of the losses and impact.
Assess	Determine the order of priority, starting with risks that have the greatest probability of occurring and incur the greatest losses.
Measures	Prepare a response manual, and carry out other preparations such as education and training.

(2)Method for operating ISMS

It is necessary to formulate a concrete basic policy and targets for information security based on the results of the risk analysis and assessment.

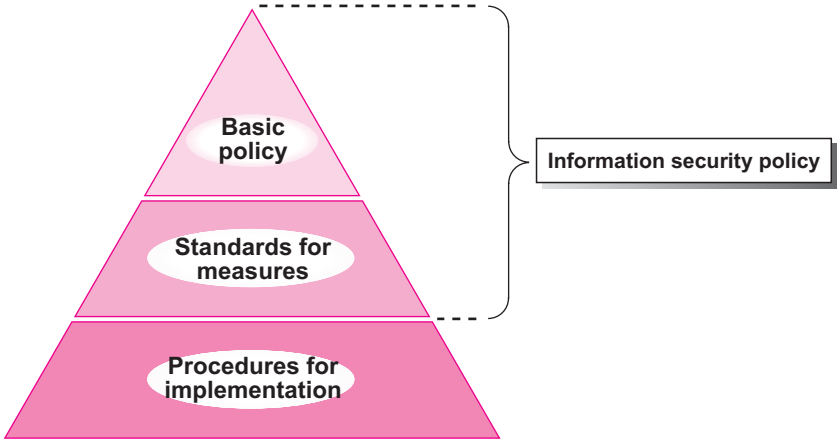
After formulating the basic policy and targets, there is a need to implement information security measures including human and physical security measures, in addition to technical measures. The information security of the organization is continuously improved through the process of verifying the results and reassessing the measures.



2 Information security policy

An **"information security policy"** explicitly describes the basic security policy of an organization in order to consistently implement information security measures throughout the organization. The information security policy explicitly describes the usage and operation of systems and the organizational framework, rather than the technical measures for information security. Under the information security policy, the organization identifies the important information assets within the organization and formulates measures that determine how the organization is to protect the assets.

The information security policy is made up of a **"basic policy"**, **"standards for measures"**, and **"procedures for implementation."** An information security policy commonly covers the **"basic policy"** and **"standards for measures."**



●Basic policy

Describes the guidelines from upper management for pursuing information security initiatives as an organization. Upper management must explain the reasons for pursuing these initiatives to the employees of the organization.

●Standards for measures

The organization establishes a concrete code and evaluation criteria in accordance with the basic policy, describing the **"information assets, threats, and degree of protection against threats."**

●Procedures for implementation

The procedures for implementation are usually not covered by the information security policy. The procedures for implementation describe the procedures for executing the contents prescribed by the **"standards for measures,"** as it relates to specific and individual work and information systems.

3 Three major elements of information security management

"Information security management" is designed to protect information assets from various threats, and secure the **"confidentiality"**, **"integrity"**, and **"availability"** of the information assets. These three elements are to be secured in a balanced manner.

●Confidentiality

Ensure that only persons authorized to have access are able to access information.

●Integrity

Protect the accuracy and integrity of information and processing methods.

●Availability

Ensure that authorized users are able to access information and related assets when needed.

❹ Personal information protection

Incidents involving the leakage of personal information are now occurring with greater frequency. As a result, corporations must protect and strictly manage personal information as part of their valuable assets. Leakage of personal information can expose individuals to various threats including nuisance telemarketing calls, large amounts of direct mail, and misleading payment notices, in addition to eroding confidence in the corporation.

●Privacy Mark System

A large amount of personal information is stored on computers today, which has increased the risk that personal information could be carelessly leaked. Due to this risk, developed countries have implemented measures such as enacting legislation for the protection of personal information. The European Parliament and Council of the EU (European Union) issued the EU Directive on the protection of individuals with regard to the processing of personal data and the free movement of such data in 1995. This directive served as the impetus for Japan to launch the **"Privacy Mark System"** in April 1998, with the JIPDEC (Japan Information Processing Development Corporation) acting as the accreditation body.

The three objectives of the Privacy Mark System are summarized below.

- **Enhance consumer consciousness toward personal information protection.**
- **Provide consumers with an index for judging the appropriateness of the handling of personal information by business operators.**
- **Bestow incentives for business operators to take measures to protect personal information.**

Under the Privacy Mark System, JIPDEC grants permission to business operators who have demonstrated that they have taken appropriate initiatives to protect personal information for using the privacy mark as a mark of accreditation. Business operators who have been granted permission to use the privacy mark may display this mark in advertising and on business cards, and on envelopes and websites to demonstrate to others that they observe the appropriate handling of personal information.

Privacy mark

Sample

* The privacy mark accreditation number shown here is a sample number. Accreditation numbers are individually assigned to business operators.

Reference

EU (European Union) directive

An "EU directive" is a form of legislation between EU member states. The 1995 EU *Directive on the protection of individuals with regard to the processing of personal data and the free movement of such data* stipulates that the transfer of personal data from an EU member state to a third country may only be made to a third country that takes adequate steps to protect personal information.

9-5-3 Information security measures/information security implementation technology

It is necessary to institute and implement information security measures from every possible perspective in order to suitably deal with a variety of threats to information security.
It is also important to institute information security measures against human, technical, and physical threats respectively.

1 Types of human security measures

The types of human security measures are summarized below.

(1)Realization of information security policy

The purpose of a security policy is to realize a unified approach to information security as an organization. There are multiple information security measures for each threat. Of these measures, an organization can achieve a unified approach to information security by pursuing **"standardization of measures as an organization."**

(2)Implementation of security education

It is important to regularly implement security education so as to raise awareness of security among users.

(3)Compliance with company regulations and manuals

The organization should prepare company regulations and manuals, and ensure strict compliance by users.
For example, there are various methods for logging on to a server such as through the use of an **"IC card"**, **"password"**, or **"fingerprint authentication."** The organization should prescribe the administration method for logging on to servers through company regulations or manuals so that it is standardized to secure unified compliance by users.

(4)Access administration

Unauthorized intrusion into a company network can lead to the possibility of theft or falsification of data in shared folders. When sharing directories or folders on a network, it is necessary to set **"access rights"** that determine who may use the directories or folders, and the extent of use. By setting access rights, it is possible to restrict the users with access and extent of use to prevent theft or falsification of data.

In addition, if there is a workplace transfer by a user, certain actions are taken such as assigning new access rights and revoking old access rights. If a user quits the company, the user ID is rendered invalid.
To verify that access rights are operating as intended, it is necessary to gather user logs and regularly audit the logs.

❷ Types of technical security measures

The types of technical security measures are summarized below.

(1)Measures for computer viruses

The infection routes for computer viruses are through removable storage (portable storage media) such as USB memory and networks.
The following are measures that can be taken to protect systems from the threat of computer viruses.

●Habitually running checks using antivirus software

"Antivirus software" is software with functions to check for infection by computer viruses, and to remove computer viruses if there is an infection. Also referred to as **"vaccine software."**
When files or e-mail are downloaded from the Internet, there is a possibility that the files or e-mail could be infected with a computer virus. Therefore, it is necessary to use antivirus software to run a virus check on the downloaded files or e-mail. In addition, infection can result from bringing in devices such as USB memory from outside the organization. Therefore, users should be conditioned to habitually run a virus check before using such devices.

●Measures to prevent virus intrusion from networks

To prevent the intrusion of computer viruses from networks, it is necessary to deploy antivirus software at appropriate points on the path of infection over networks. Specifically, antivirus software should be deployed for firewalls that are the sole path connecting internal networks to the Internet, and on public servers, company servers, and clients. These steps are taken to minimize the scope of infection from a computer virus. It is also necessary to create a framework to automatically distribute antivirus software to these resources so that every resource is updated to the most recent software version and pattern file (virus detection data).

Reference

OS (Operating System) updates

A type of bug known as a "security hole" is sometimes discovered in OSes and e-mail software. When a security hole is discovered, the OS developer distributes an updating program on its website in order to repair the security hole. The updating program can be downloaded and installed to repair the security hole, and restore security to the OS. It is important to regularly update the OS.

Reference

Signature code

A "signature code" describes the characteristics of a virus, and is stored in pattern files.

Reference

Basic measures following virus infection

- Removable storage media that contains an infected program should basically be destroyed, as there is no assurance that initializing the media will completely remove the computer virus.
- If a fixed disk within a system is discovered to be infected with a virus, follow the instructions issued by the security administrator for dealing with the problem.
- Follow the instructions issued by the security administrator when attempting to restore backup systems and other systems, taking into account that the infection could spread.

●Measures to prevent spread of damage following virus infection

If a situation that points to a computer virus infection is discovered, the first step it to stop using the system, then notify the security administer and follow instructions as necessary. If the system is connected to a network, the connection should immediately be severed to prevent the infection from spreading.

(2)ID and password management

A **"user ID"** is a user name that is assigned in order to identify the system user. A **"password"** is used to authenticate the user and prove that it is the correct user. The system validates that it is the user only when the user ID and password match.

●Password setting and management

Under user ID and password management, permission to use a system is only granted when a user enters the correct user ID and password combination. Therefore, it is necessary to set a password that is difficult for others to guess.

Easy passwords to guess	· Own name or date of birth · Telephone number · Employee number or company name · Address · Commonly used word · Repeat characters · Few characters
Difficult passwords to guess	· Combination of multiple words · Combination of alphanumeric characters and special symbols · Character string containing eight characters or more

The following precautions should be observed for password management.

•Always set passwords. (Do not permit blank passwords.)
•Change passwords on a regular basis.
•Do not write down passwords on a piece of paper or other material.
•Do not set shared passwords for an entire organization, etc.
•Do not respond to inquiries over the phone.
•Do not send passwords by e-mail.

Reference

Measures for when a network system is infected by a virus

- Issue instructions to stop using the system, and sever the system from the network.
- Investigate the route of infection, possible scope of infection, and type of computer virus, and notify relevant departments and network users of the virus infection.
- Implement measures such as restricting use of the network.

Reference

One-way hash function

A "one-way hash function" is a function that converts an entered value into another value in such a way that it is not possible to derive the entered value through reverse conversion of the converted value.

Reference

One-time password

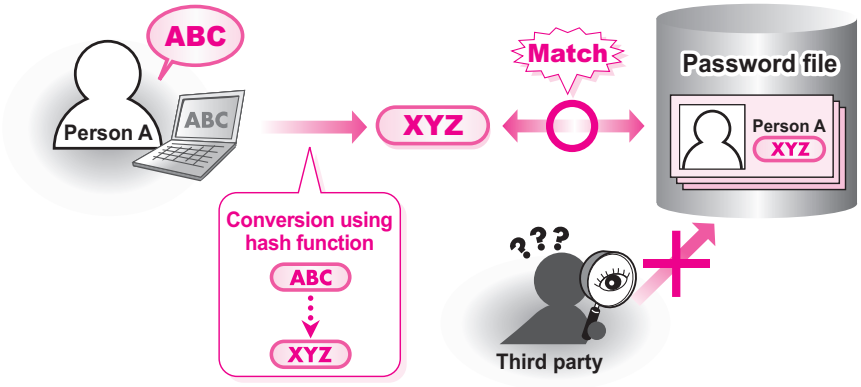
A "one-time password" can be used for one login session only, after which it is discarded. The password is generated using a piece of hardware called a password generator.

The advantage of a one-time password is that security is not compromised if the one-time password is leaked, as the password is changed for each login.

●Response by security administrator

A security administrator, regardless of position, must not know the passwords of users, due to the risk of password leakage. If a password is forgotten by a user, the old password should be initialized and rendered unusable, and the user should personally reset the password. The security administrator should not be the one to set a new password.

It is also necessary to take measures to ensure that the contents of password files used for password registration cannot be immediately deciphered in case the password files are stolen, and to prevent malicious use of the passwords. One method is to encrypt the passwords in advance. A **"one-way hash function"** is often used to prevent the deciphering of encrypted passwords.



Reference

SSL

"SSL" is a protocol developed by Netscape Corporation to provide communications security for the transport layer of TCP/IP. Specifically, SSL is used to encrypt the sending and receiving of information between an Internet server and a Web browser so that a third party cannot use the information for malicious purposes.

Abbreviation for "Secure Sockets Layer."

(3)Use of encryption

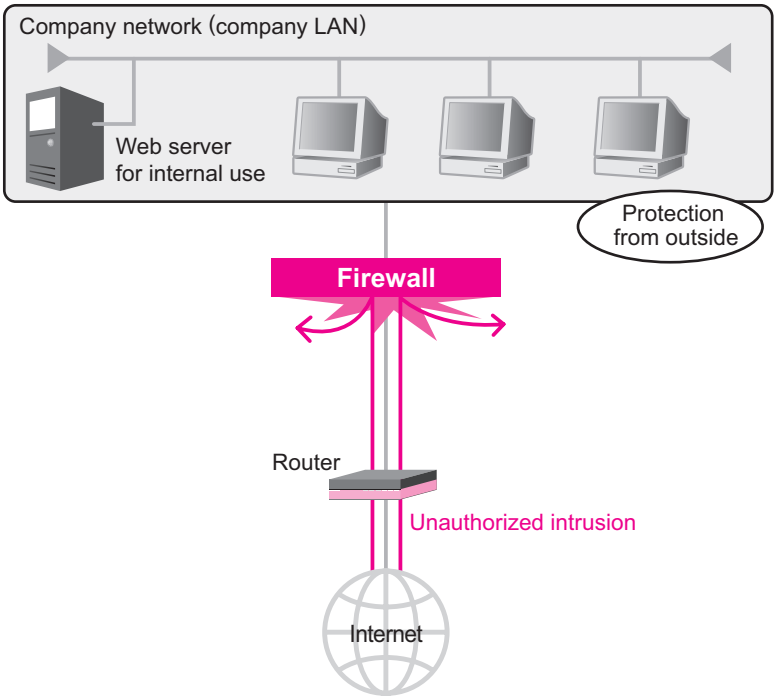
"Encryption" is the process of converting information into a format that cannot be leaked to a third party when exchanging data over the Internet. Using encryption during communications can prevent the theft of information.

(4)Setting a firewall

A **"firewall"** is a system that prevents unauthorized intrusion from the Internet. It functions as the entry and exit point between a company network and the Internet in order to monitor communications and block unauthorized communications.

The most basic function of a firewall is **"packet filtering,"** which searches for information such as the IP address of packets, as well as TCP port numbers and UDP port numbers. Only packets that contain a previously registered and permitted IP address, TCP port number, or UDP number are allowed to pass through the firewall. This prevents the intrusion of packets that do not have permission.

A router can also be used to provide this function. However, the difference between a router and firewall is that a router is designed in principle to let all packets through, which makes it necessary to register packets that are to be blocked. In contrast, a firewall is designed in principle to block all packets, which makes it necessary to register the packets that are to be let through.



(5)Installing a proxy server

A **"proxy server,"** also called an **"application gateway,"** is a server that acts as a communications gateway for company computers to access the Internet.

●Communications gateway

When a company computer connects to the Internet, the connection is routed through a proxy server acting as a gateway. Using a proxy server as a gateway makes it possible to conceal the IP address of each computer (private IP address). From the perspective of the Internet, communications are conducted with the proxy server, which reduces the risk of attacks on company computers.

In addition, a proxy server can temporarily store (cache) data that has been accessed, which speeds up the process when accessing the same data the next time.

Reference

Security settings for e-mail and Web browsers

E-mail software and Web browsers provide functions for setting the security level of the software. Setting a high security level can help to prevent intrusion from viruses, hackers, etc.

●Content filter

A **"content filter"** is a function that blocks inappropriate content to prevent leakage of information. For example, an educational institution may place restrictions on accessing harmful Web pages to discourage viewing of certain sites such as those containing adult or violent content. This can be accomplished by preparing a list of URLs of harmful Web pages and blocking access to them, or blocking access to Web pages that use specific words or phrases. Corporations also use content filtering to ban the viewing of Web pages that are unrelated to work, or to prevent leakage of information through message boards or blogs.

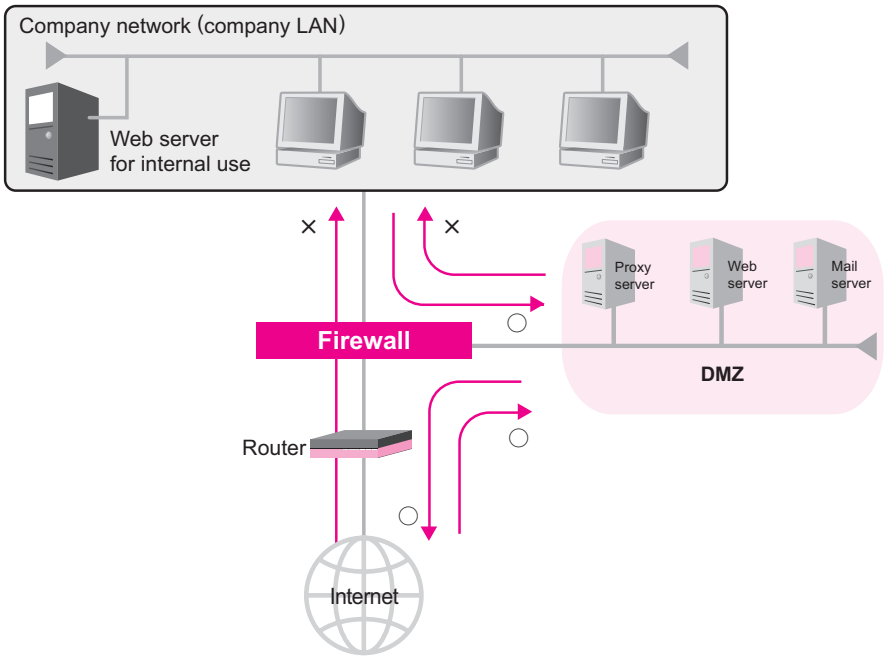
(6)DMZ

Reference

DMZ

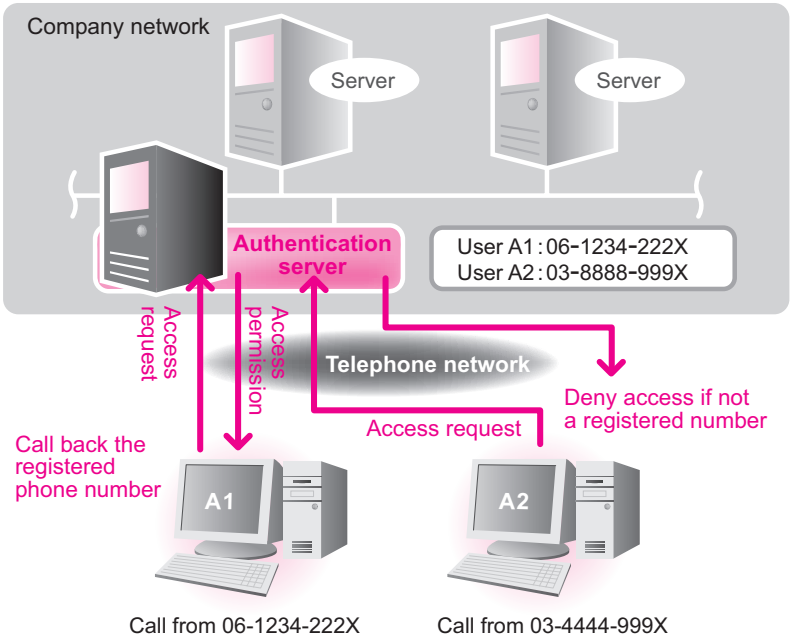
Abbreviation for "DeMilitarized Zone."

A **"DMZ (DeMilitarized Zone)"** is an area of a network that is established between the company network and an external network such as the Internet. Web servers, mail servers, and proxy servers that a corporation publishes over the Internet are situated in the DMZ. A server that is published in the DMZ can be accessed from company networks, while also permitting access from the Internet. It is also permitted to access the Internet through the DMZ, but company networks cannot be accessed through the DMZ. Establishing a DMZ is useful for preventing the spread of damage to company networks, if a server published on the Internet is compromised through unauthorized access.



(7)Callback

"Callback" is a system in which the user connects to the authentication server of a company network from outside the company. The line is then severed and the authentication server calls back the user. It can be used to verify whether the caller is a valid user by configuring the callback system to deny network access to anyone whose number has not been registered to the system. It can also be used to reduce communications costs for users.



3 Types of physical security measures

The types of physical security measures are summarized below.

(1)Biometric authentication

"Biometric authentication" is a matching technology that is used for identification, and is based on physical characteristics that are unique to each person such as fingerprints or veins.

The advantages of identification based on physical characteristics are strong security and inability to forget the identification. Currently, research is being conducted on a variety of technologies, which is gradually making it possible to implement biometric authentication as technical hurdles, and clear cost issues. However, there are various outstanding issues such as support for persons who cannot use biometric authentication due to illness or injury. In addition, there are other issues dealing with secular changes in physical characteristics, and management of biometric information that has been previously registered.

Reference

RAS

A "RAS" refers to a dial-up connection service for computers in a remote location, using telephone lines or ISDN lines. It allows users to take advantage of resources on company networks by connecting to a company authentication server from outside the company.
Abbreviation for "Remote Access Service."

Reference

Biometric authentication

"Biometric authentication" was coined from the words "biology" and "metrics."

Reference

Secular change

"Secular change" refers to the changes that occur over the passage of time.

Reference

Feature extraction

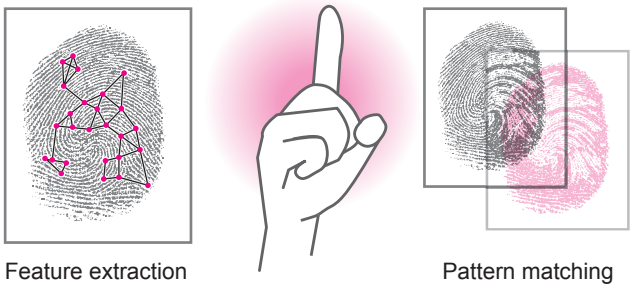
"Feature extraction" is a method of extracting the features of a fingerprint pattern such as where a ridge terminates or splits in order to compare fingerprints.

The typical types of biometric authentication in practice are summarized below.

●Fingerprint authentication

Fingerprint authentication is the most prevalent form of biometric authentication and is used in laptop computers and mobile phones due to the small size and comparatively low price of the authentication devices.

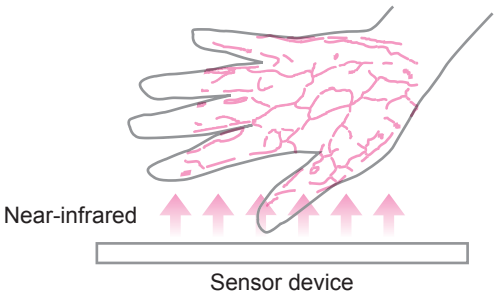
Methods of fingerprint authentication include feature extraction, which involves extracting and matching features from fingertip patterns, and pattern matching, which provides matching by superimposing images of fingerprint patterns.



●Vein authentication

Vein authentication is a method for matching vein patterns, utilizing the property of blood flowing in veins to absorb near-infrared light. Matching is performed using finger and palm vein patterns. Palm vein authentication delivers higher accuracy than finger vein authentication, as there are many thick veins in the palm.

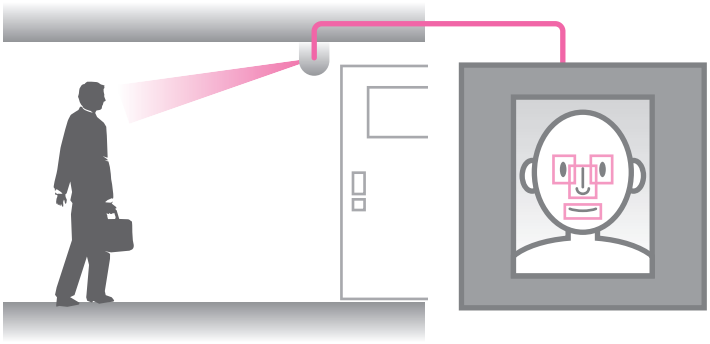
Vein authentication is used in a wide range of fields such as bank ATMs since there is less psychological resistance to using the technology. Vein patterns are invisible to the eye and there is not as much of an association with crime investigation. Contactless sensor devices have been developed for improved hygiene.



●Face authentication

Face authentication is a method for matching face patterns by extracting the features of face parts such as the eyes and nose.

Face authentication is performed by requiring the person to stand in front of a camera for authentication, or through automatic authentication as the person walks through a hallway. It is used for applications such as airport check-in and entrance access control, and customer management.

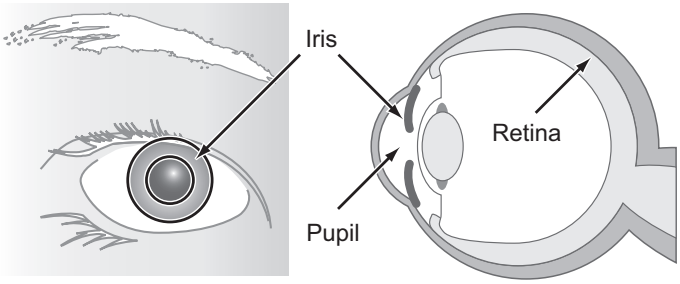


●Retina/iris authentication

The **"retina"** is a thin lining at the back of the eyeball. Retina authentication involves matching the pattern of capillary vessels in the retina.

The **"iris"** is a circular lining that adjusts the contraction and dilation of the pupil. Iris authentication involves matching the pattern of the iris.

Although there is variance between the left and right retinas and irises on the same individual, it does not change with the passage of time. For this reason, retina and iris authentication are used as a means of entrance access control for confidential areas of government and business.



(2)Entrance access control

"Entrance access control" refers to control over the movement of people, with respect to who has access, and when and where the access takes place. It can also be used as a measure against suspicious individuals. Only authorized persons can be permitted access to buildings or rooms where important or confidential information is handled, and it is necessary to keep records of entrance access.

●Locking

Locking is the basic method of entrance access control. Just as a password is set for a computer, facilities such as buildings, rooms, and lockers are locked in order to prevent intrusion from the outside and use by unauthorized persons. In consideration of user convenience, electronic locks are increasingly being used.

●Unlocking

An electronic key is used to unlock and enter a room that is kept locked using an electronic lock. There are various types of electronic keys including IC cards, security codes, and biometric authentication, which can be chosen based on the desired level of security and convenience to users. Since a suspicious person could gain access by slipping behind a valid user who has unlocked the access, other measures are required such as installing a gate that only allows one person through, or installing surveillance cameras.

●Keeping records of movement

The movement of people is recorded with respect to who has access, and when and where the access takes place. This information can be handwritten on a paper list but due to its inconvenience, users are increasingly failing to record the information properly, which could prevent strict entrance access control.

Currently, it is standard practice to have a system in place that records the time, user, and place when an electronic key is unlocked. These records can also be combined with attendance-related processing.

IC tags can be used to record movement in a more precise manner. IC tags contain a tiny chip that can be used for radio wave transmission. When a user who wears an IC tag passes near an IC tag reader, the reader automatically records the movement. This system can be used to record the movement of multiple persons who pass by the reader at the same time, making it a useful solution for recording the movement and whereabouts of persons.

Reference

Use of IC cards

An "IC card" is a card the size of a business card and contains an integrated circuit (IC) or chip. They are often built into employee identification cards, and are used for personal identification purposes. In addition, IC cards are often used in combination with a "PIN (Personal Identification Number)" as a precaution against theft.

Reference

Installation of surveillance cameras

It is also effective to install cameras and video cameras in order to implement surveillance of suspicious individuals. Surveillance cameras are installed in places such as near doors and other entrances, or where confidential information is stored. This can help to prevent theft and information leakage.

Reference

Measures for physical security control

The *Guidelines for Personal Information Protection Laws Concerning Fields of Economy and Industry* defines measures for physical security control as "measures such as to control room or building entrance access and prevent theft of personal data." These guidelines state that the following measures are to be instituted. "1) Implementation of entrance access control for building or room, 2) prevention of theft, etc. and 3) physical protection such as of equipment and devices." A physical measure refers to the control of physical elements such as persons, equipment, buildings, and rooms. These measures are used to determine the persons that accessed buildings or rooms containing equipment on which personal information is stored, and when the access occurred. These measures are also used to determine if rooms containing equipment are locked, and if equipment is fastened or chained down to prevent removal.

4 Encryption technology

"Encryption" is the process of converting plaintext (source text) into different data. Decryption is the process of returning the encrypted data to plaintext. A key is required for both encryption and decryption.
Approaches for encryption include **"common key cryptography"** and **"public key cryptography,"** which are distinguished by their respective use of keys.

(1)Common key cryptography (Secret key cryptography)

"Common key cryptography" is an approach that uses the same key (common key) for encryption and decryption. The common key must be confidentially shared since it is not possible to prevent interception or falsification if the key becomes known to a third party.
For this reason, common key cryptography is also called **"secret key cryptography"** and **"shared key cryptography."** The **"DES (Data Encryption Standard)"** is a commonly used method of common key cryptography.
The framework and characteristics of communications using common key cryptography are summarized below.

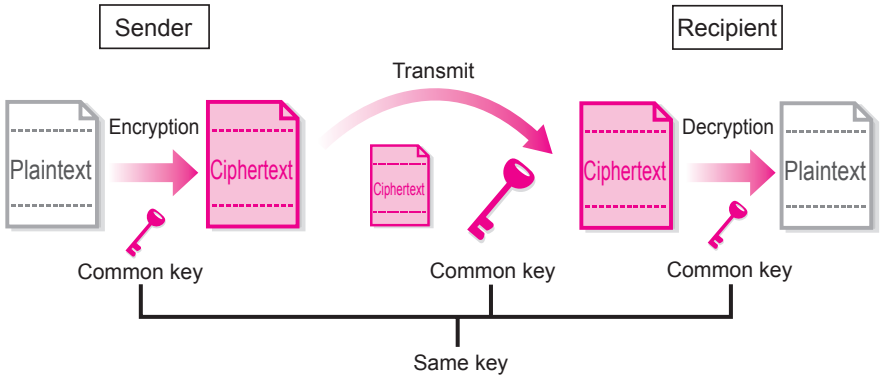
Sender generates a common key, and confidentially transmits the common key to the recipient.

The sender sends the ciphertext that was encrypted using the common key.

The recipient decrypts the ciphertext using the common key.

●Characteristics

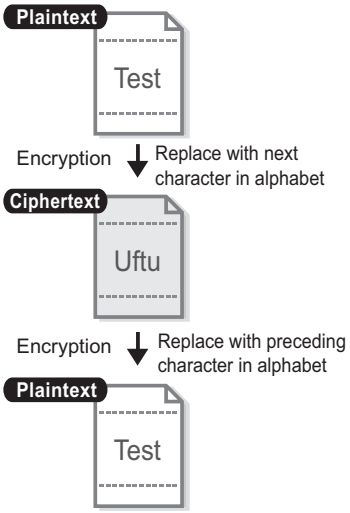
•Fast encryption and decryption speed.
•Risk of leaking the common key when the common key is transmitted.
•Need to prepare separate common keys for each communicating partner.



Reference

Encryption example

Encryption by "replacing each character with the next character" in the alphabet.



Reference

DES

Abbreviation for "Data Encryption Standard."

Reference

PKI

"PKI" refers to the overall technology and product infrastructure for using public key cryptography. It encompasses technologies for public key cryptography such as RSA, browsers that incorporate SSL, e-mail encrypted using a standard such as S/MIME, and servers of certification authorities that issue digital certificates. It was proposed as a solution to enable the secure execution of electronic commerce.
Abbreviation for "Public Key Infrastructure."

Reference

RSA

"RSA" is a method for public key cryptography that was developed with a focus on the challenge of factoring large numbers into its prime components.

Reference

CA

A "CA" is an entity that issues certificates that attest to the validity of a public key used for purposes such as public key cryptography or digital signatures.
Abbreviation for "Certification Authority."

(2)Public key cryptography

"Public key cryptography" is an approach that uses different keys (secret key and public key) for encryption and decryption. The secret key is for personal use and must not be shared with a third party. The public key is widely published to third parties, and is registered with a certification authority for publication.
"RSA" is s method that is typically used for public key cryptography.
The framework and characteristics of communications using public key cryptography are summarized below.

The recipient generates a secret key and public key, and registers the public key to the public key list of a certification authority. The recipient then receives a certificate.

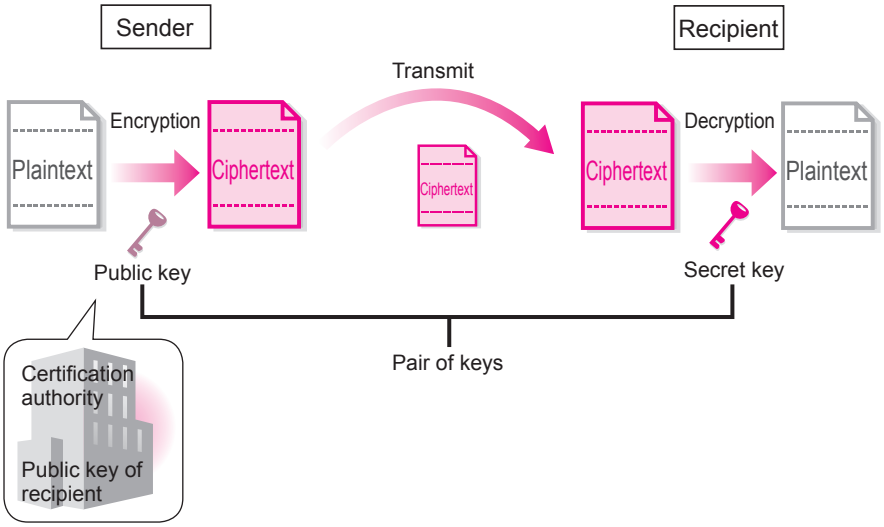
The sender takes the recipient's public key from the public key list of the certification authority.

The sender sends the ciphertext encrypted with the recipient's public key.

The recipient uses their own secret key to decrypt the ciphertext.

●Characteristics

- **Uses a public key which is suited for communications with many recipients.**
- **Easy to manage keys.**
- **Slow encryption and decryption speed.**



(3)Other cryptography approaches

Another approach to cryptography is **"session key cryptography,"** which combines the approaches of common key cryptography and public key cryptography. It is also referred to as a **"hybrid cryptography"** approach. The session key cryptography takes advantage of the fast encryption speed of common key cryptography, and the ease of key management under public key cryptography, combining the approaches to provide a more practical approach to encryption.

The framework and characteristics of communications using session key cryptography are summarized below.

Sender encrypts plaintext using a common key.

↓

Sender transmits the common key that has been encrypted using the recipient's public key.

↓

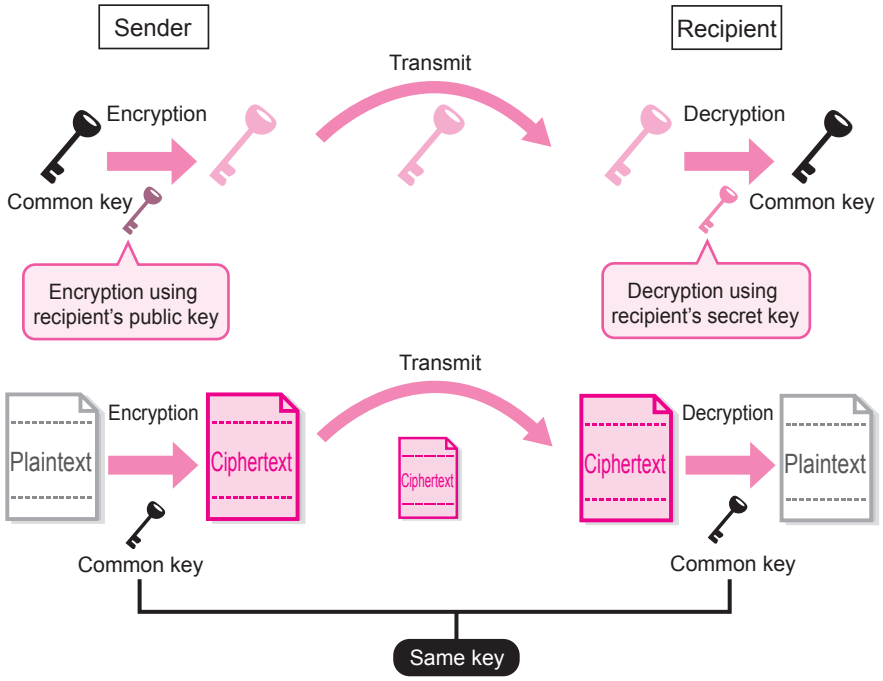
The recipient decrypts the common key using their own secret key.

↓

The recipient decrypts the ciphertext using the common key.

●Characteristics

- **Uses common key cryptography for fast encryption and decryption speed.**
- **Uses public key cryptography to enable confidential notification of common keys.**



Reference

Digital signature

A "digital signature" refers to information that is appended in order to attest to the validity of electromagnetic records (digital documents). A digital signature has the same effect as a seal or signature that is used to attest validity in daily life. A digital signature is achieved through the combined use of a message digest and common key cryptography.

The characteristics of a digital signature are summarized below.

- Sender uses a secret key for encryption so that it is possible to attest that it is the sender.
- The message digest is compared to attest that the data has not been falsified.

Reference

Message digest

A "message digest" is compact data that contains a summary of the original plaintext. A hash function is used to summarize the original plaintext. It is not possible to generate the original plaintext from the message digest, while even a single change in the original plaintext completely changes the values of the message digest. Therefore, the message digest before transmission and after transmission can be compared to attest that the data has not been falsified.

9-6 Chapter quiz

*See page 15 in the "Answers and Explanations" booklet for the correct answers.

9-1 Which of the following is the appropriate GUI (Graphical User Interface) component used to select one from multiple alternatives?

a) Scroll bar
b) Push button
c) Progress bar
d) Radio button

9-2 In screen design, in which of the following situations would it be better to select an option from a list of candidates than enter data directly?

a) In the situation where each input item must be checked or corrected
b) In the situation where large amounts of data such as sentences are entered
c) In the situation where many different values are valid as input data
d) In the situation where the types and content of input data are limited

9-3 When Web pages are created with due consideration for ease of use, which of the following points should be kept in mind?

a) The fundamental screen structure and buttons should be displayed and placed in an easily understood manner on each page, without unifying the whole website.
b) When there are many options, they should be divided into groups or hierarchies to make them easy to select.
c) The title of a page should be named so that the developer can understand easily when the page contents are updated.
d) When you want the user to move to another page, you should make the page switch automatically, rather than prompt the user to select the link for the destination.

9-4 Which of the following is the appropriate description concerning the JPEG format?

a) It is an encoding format for images with up to 256 colors.
b) It is an encoding format for audio.
c) It is an encoding format for static images.
d) It is an encoding format for video.

9-5 Which of the following is a device that is used for catching image projected from imaging equipment such as a video cassette recorder and storing it on a computer as digital data?

a) Capture card
b) Scanner
c) Sound card
d) Tablet

9-6 Which of the following is the appropriate explanation of virtual reality?

a) It enables recognition of the overall picture immediately not by displaying an image from the top gradually but by displaying a coarse mosaic-like image first and then displaying a clear and vivid image gradually.
b) It enables seeing and hearing the objects and spaces that are generated by computers like the actual world using computer graphics etc.
c) Instead of the wind tunnel test used for the design of cars and airplanes, it conducts simulation tests using computers.
d) It creates the composite image of scenery and people shot separately to make an image that is different from the real world.

9-7 Which of the following is appropriate as a role that a database management system plays?

a) It compresses data to increase the available capacity of a disk.
b) It encrypts the data transmitted to a network.
c) It enables multiple computers to share a magnetic disk.
d) It enables multiple users to share a large amount of data.

9-8

In handling a database, the key to specify a record is required. Which of the following is the appropriate key to specify a record in the student management table of a certain school year?

a) Name
b) Address
c) Student number
d) Birth date

9-9

Which of the following is the membership number of the woman whose present address and work location are both Tokyo in the member list table?

Member list

Membership number	Name	Sex	Present address	Work location
0001	Akio Tanizawa	Male	Saitama Prefecture	Tokyo
0002	Masato Toyonaga	Male	Tokyo	Tokyo
0003	Mayumi Akiyama	Female	Chiba Prefecture	Saitama Prefecture
0004	Yuka Kasai	Female	Tokyo	Tokyo
0005	Kenta Yamauchi	Male	Saitama Prefecture	Saitama Prefecture
0006	Nobuko Yamamoto	Female	Chiba Prefecture	Tokyo

a) 0001
b) 0003
c) 0004
d) 0006

9-10

Which of the following product groups can be found when searching the "Product Inventory" table for products with a sales price of 500 dollars or more per unit and an inventory of less than 10 units?

Product Inventory

Product Code	Product Name	Manufacturer	Sale Price	Inventory	Inspector
100	Large refrigerator	AAA	300,000	10	Smith
110	Medium refrigerator	AAA	200,000	6	Smith
120	Small refrigerator	BBB	100,000	8	Smith
130	Portable refrigerator	BBB	40,000	3	Smith
200	Air purifier	CCC	60,000	22	Miller
210	Air ionizer	DDD	45,000	18	Miller
300	Coffee maker	EEE	15,000	5	Johnson
400	Air conditioner	FFF	120,000	7	Brown

a) Large refrigerator, medium refrigerator, small refrigerator, air purifier, and air conditioner
b) Large refrigerator, medium refrigerator, small refrigerator, portable refrigerator, air purifier, coffee maker, and air conditioner
c) Medium refrigerator, small refrigerator, and air conditioner
d) Medium refrigerator, small refrigerator, portable refrigerator, coffee maker, and air conditioner

9-11

Which of the following is the problem that may occur when multiple users change one file and overwrite it concurrently?

a) Many files with the same name are created and the users cannot distinguish them.
b) Only the contents overwritten by the last user remain, and the previous modifications are lost.
c) The file is moved onto the PC of the user who modified the file previously, and other users cannot find the file.
d) Modified contents are automatically added at the end of the file and the file size increases.

9-12 Which of the following is the appropriate explanation of LAN?

a) The protocol for transmitting and receiving e-mails on the Internet
b) The network that provides "high speed" communication between the computers in a comparatively narrow area, such as inside of the same building
c) The network that connects geographically distant Base *A* and Base *B* using telephone lines or dedicated lines to provide communication
d) The standard protocol of the Internet used for network control

9-13 What is the convention and rules that both sides should observe about error detection, re-transmission control, and selection of communication pathways for data flowing through channels, in communication between computers via a network?

a) Address
b) Interface
c) Domain
d) Protocol

9-14 Which of the following is indicated by URLs, which are used on the Internet?

a) E-mail addresses for use in the Internet
b) Information sources (resources) on the Internet
c) IP addresses of servers connected to the Internet
d) Owners of PCs connected to the Internet

9-15 When Mr. *A* sent an e-mail to Mr. *B*, Mr. *A* specified Mr. *C* as "cc" and Mr. *D* and Mr. *E* as "bcc." Which of the following is an appropriate explanation at that time?

a) Mr. *B* understands that the mail from Mr. *A* was sent to Mr. *D* and Mr. *E*.
b) Mr. *C* understands that the mail from Mr. *A* was sent to Mr. *D* and Mr. *E*.
c) Mr. *D* understands that the mail from Mr. *A* was sent to Mr. *E*.
d) Mr. *E* understands that the mail from Mr. *A* was sent to Mr. *C*.

9-16

When you send broadcast mails to a large number of predetermined people, which of the following is used to specify the destinations easily?

a) bcc
b) Mailing list
c) Mail transfer
d) Mailbox

9-17

Which of the following describes social engineering?

a) It collects a user's personal information via a questionnaire on a website.
b) It analyzes the utilization history of on-line shopping to predict the product that the customer is likely to buy.
c) It collects the e-mail addresses publicly available on the website to transmit the e-mails for advertisements to many people.
d) It picks a piece of paper on which a password is written out of a trash can to obtain a user's password, and pretend to be the user when using a system.

9-18

Which of the following is the appropriate description concerning formulation of the information security policies in a company?

a) They are common in each type of industry, so creating original policies in each company is not required.
b) They are created by a system administrator and care must be taken not to let anyone else know about them.
c) The concepts and measures for information security in the company are clearly described in a document.
d) The configuration of a firewall is determined and documented.

9-19

Which of the following is the most appropriate description concerning management of the user IDs and passwords in system operations?

a) Each business system uses a different user ID and password. The user must carry a list to prevent input mistakes.
b) The company prompts all the employees to change their passwords periodically, and the users themselves change their passwords.
c) A system distributes the word chosen from the dictionary at random to each user. The user uses it for a password up to a periodic date of update.
d) The users are encouraged to use a numeric string that is easy to memorize and easy to use, such as their birthdays and telephone numbers, as their passwords.

9-20

If a user at an enterprise forgets his/her own password, which of the following is an appropriate way in which a security administrator should inform the user of his/her passwords after confirming his/her identity?

a) A security administrator retrieves the password which is stored on his/her own computer, and then sends it to the user in the form of an internal document classified as confidential.
b) A security administrator informs the user of an initial value after initializing the user's password, and then the user changes it to a new password.
c) A security administrator makes a copy of the password, which is stored in an encrypted form, in the common area, and then informs the user of the decryption key by telephone.
d) A security administrator decodes the password which is managed in an encrypted form, and then informs the user of that password by e-mail.

9-21

Which of the following is the appropriate description of measures against computer viruses?

a) Virus checking is unnecessary while the PC is operating normally.
b) The virus definition file in antivirus software is updated to the latest one.
c) Virus checking is unnecessary if the digital signature is attached to the program.
d) Virus checking is unnecessary for the software that one of your friends gave you.