4 Memory, Storage Devices and Data Representation

Like human beings need to memorize things, which can be retained and recalled on need, computers also need to store data and instructions for future use. Memory is a part of computer where data and instructions are stored. A computer deals with different type of memories. Two major types of computer memories are (i) primary (main) memory and (ii) secondary (auxiliary) memory. Information in a memory of a digital computer is stored in form of binary digits (0 and 1). These binary digits in short are known as bits. A bit is a binary digit, which is either 1 or 0. A group of 8 bits is known as byte. Storage capacity of a computer memory is measured in terms of the bytes in form of kilo bytes (KB), mega bytes (MB) and giga bytes (GB). Consider Table 4.1 that shows the relationship between these terms.

1 bit = a single digit, either 1 or 0
8 bits = 1 byte, combination of 1's and 0's
2^{10} Bytes = 1024 Bytes = 1 KB (kilobyte)
2^{20} Bytes = 1024 Kilobytes = 1 MB (megabyte)
2^{30} Bytes = 1024 Megabytes = 1 GB (gigabyte)
2^{40} Bytes = 1024 Gigabytes = 1 TB (terabyte)

Table 4.1 : Storage Capacity Measures of Computer Memory

Primary Memory

Primary memory, also known as main memory, is an important part of a computer in which data is stored for quick access by the computer's processor. It is made of larger number of cells. Each cell is identified by a number called an address of the cell. Each cell contains a piece of data. When there is a requirement of the data, the cell address is used to retrieve the data. The primary memory is organized in such a fashion that the time required to store or retrieve data from a cell is independent of the cell addresses. That is, any location of the memory can be chosen randomly for use. This is known as Random Access Memory (RAM). There are other access methods which are not random. For example sequential access, First In First Out (FIFO) access and Last In First Out access (LIFO). In sequential access memory, data is stored serially or sequentially in a long string. When you want to access some part of the string, you have to pass through the previous part of the string. Just like in an audio tape, if you want to hear the third song, first two songs must be fast forwarded. FIFO is just like queue, where first entry will be served first and last will be entertained at last. LIFO is like tray (or pile) of papers. The paper which you had put at last will come out first. Figure 4.1 shows FIFO and LIFO access mechanisms.

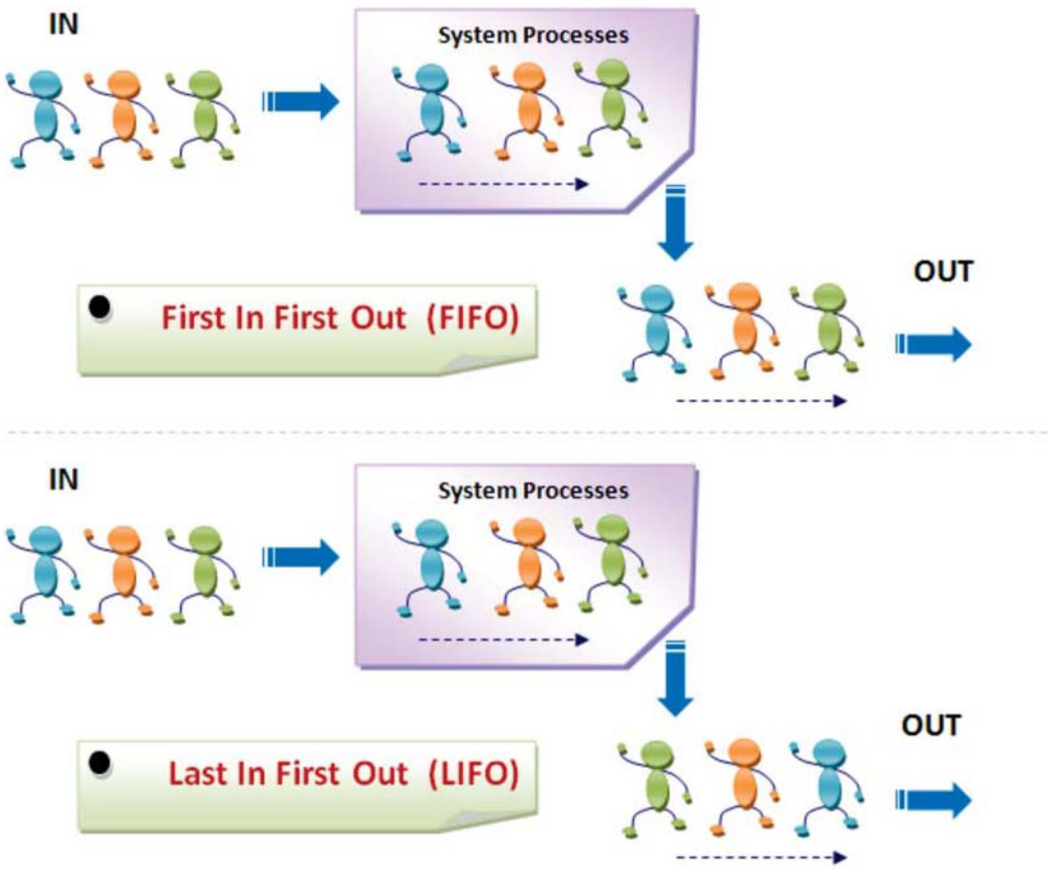


Figure 4.1 : LIFO and FIFO Access Mechanism

RAM is volatile memory. The content written in RAM requires continuous power supply to retain it into the memory. On modern computers the term RAM - or just memory - is used instead of primary or main storage, and the hard disk, diskette, CD, and DVD collectively describe secondary storage or auxiliary storage. Figure 4.2 shows a RAM chip.

Figure 4.2 : A RAM Chip

There are two basic types of the RAM. The first one is static and second is dynamic. Dynamic RAM (DRAM) needs to be refreshed thousands of times per second. Static RAM (SRAM) does not need to be refreshed, which makes it faster; but it is more expensive than dynamic RAM. Both types of RAM are volatile, meaning that they lose their contents when the power is turned off.

Computers also contain Read Only Memory (ROM) which are used to permanently record data and instructions. Content of ROM can only be read. Unlike RAM, ROM retains its content even when the computer is turned off. ROM is an ideal memory to store critical instructions into the computers such as boot programs (programs that start up the computer system), printer driver files, and fonts. A variation of a ROM is a Programmable Read Only Memory (PROM). PROMs are manufactured as blank chips on which data/program can be written with a special device called a PROM programmer. There is a special type of PROM called Erasable PROM (EPROM). An EPROM allows the content of PROM erased by exposing it to ultraviolet light. Instead of ultraviolet lights, electric signals are used to erase content of PROM. Such memory is called Electrically Erasable PROM (EEPROM). EEPROMS are very useful in manufacturing USB pen drives, cellular phones (memory card in mobile phone), digital cameras, portable MP3 players and microSD cards. Figure 4.3 shows typical microSD (memory) card. Special readers are available that read directly from the card.

Figure 4.3 : A MicroSD Card and Card Reader

The concept of the Read Only Memory (ROM) can be utilized to create a firmware- hardware utility with some software instructions in an integrated fashion. Firmware is to be stored on non-volatile memory devices such as ROM, EPROM, or flash memory. As mentioned in the previous chapter, such firmware are developed by the hardware manufacturing company and provided free while one purchases the hardware. Another alternative is to download such firmware from company's online store or website. Many times firmware needed to be updated as and when you change the hardware device. Many mobile phones use Firmware Over The Air (FOTA) to update the mobile firmware which makes the activity independent of cables, computers and third party software.

The firmware normally supports functions such as controlling the hardware and facilitating use of the hardware. Because of this reason users are not generally allowed to change the firmware. Most of the companies would like to store firmware in hidden fashion in order to make the system transparent from user and reduces complexity to work. For example, washing machine, traffic lights, digital camera and microwave oven have some utilities such as quick wash in washing machine and alarm in microwave oven. These basic utilities are not to be changed. However, users may add their contacts, messages, videos and pictures into the mobile phone memory. On the other hand, software programs written by users such as super store bills, pay-slip and mark-sheet printing can be changed by the users provided they have source code for the software.

There is a special high-speed storage mechanism called cache. Cache memory is small and high speed memory within the computer central processing unit for frequent access. The purpose of such memory is to increase speed of computer processor. When the processor needs to perform any read write operations, it first checks the cache memory. Table 4.2 shows differences between RAM and ROM.

RAM	ROM
RAM is random access memory.	ROM stands for read only memory.
RAM supports reading and writing operations into the computer.	ROM supports only read option.
Data and instructions are stored into it during its operation.	Instructions are stored into it during its manufacturing.
It is volatile memory.	It is non-volatile memory.

Table 4.2 : Differences Between RAM and ROM

Secondary Memory

Primary memory is generally costly and has capacity limitation, further it cannot retain data for longer period of time. However, we need to store data and instructions for long time so that they can be used later. For this purpose, secondary memory /secondary storage is used. The secondary storage stores large amounts of data, instructions, and information permanently. The popular secondary storage devices are hard disk, compact disks (CDs), digital versatile disks (DVDs), and pen drives.

Secondary memory is not directly accessible to processor of a computer but requires use of computer's input/output channels. Such memory is usually slower than primary memory but it always has higher storage capacity. Further, the secondary storage memory is non-volatile. Data remains unchanged even after switching off the computer. Secondary memory/storage is also known as auxiliary memory/storage. Figure 4.4 represents memory hierarchy.

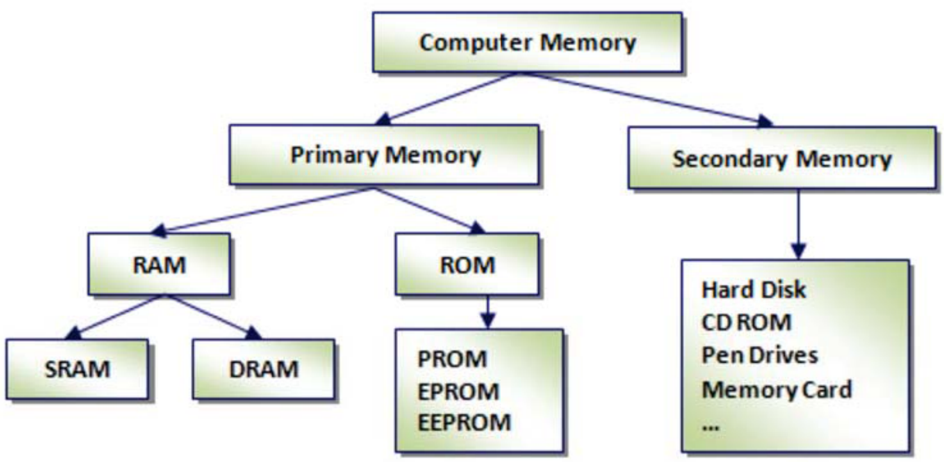


Figure 4.4 : Memory Hierarchy

Let us now have a look at some of the secondary storages.

Hard Disk

A hard disk consists of one or more rigid metal (or glass) plates coated with a metal oxide material that allows data to be magnetically recorded on the surface of the platters. Figure 4.5 shows a typical hard disk. Data and instructions are recorded on the oxide based surface by magnetising selected particles of the surface. The particles retain their magnetic orientation until that orientation is changed. Thus, hard disk allows modification once the content is stored. A hard disk platters spin at a high rate of speed, typically 5400 to 7200 revolutions per minute (RPM). Along with one or more platters, a hard disk also contains some read-write heads which read and write data on the disk platters.

Figure 4.5 : Hard Disk

Storage capacities of hard disks for personal computers range from 10 GB to 500 GB. The disk provides storage area within the computer itself. Hard disk is also known as a hard drive. Most of the hard disks are the part of computer. However, external hard disks of different sizes and capacities (such as 350 GB, 500 GB, and 1 TB) are also available. Figure 4.6 shows view of some such external drives.

Figure 4.6 : External Hard Disks

Compact Disk (CD)

A compact disk (CD) is also called an optical disc. It is a flat, round, and portable storage medium that is usually 4.75 inches in diameter. You might have seen the audio CD for music. CD can contain other types of data such as text, graphics, and video. The typical capacity of a CD is 650 MB of data.

Unlike hard disk, CD supports optical storage. Here, data is burned into the storage medium using beams of laser light. The burns form patterns of small pits in the disk surface to represent data. The pits on optical media are permanent, so the data cannot be changed. Optical media are very durable, but they do not provide the flexibility of magnetic media such as modification of data. Figure 4.7 shows typical compact disk.

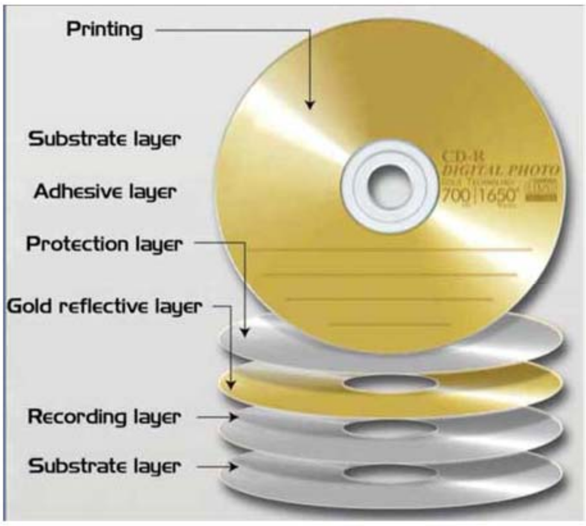


Figure 4.7 : Compact Disk

There are three popular types of optical disks; namely CD ROM, CD R and CD RW. CD-ROM is the most popular type among them. CD-ROM stands for Compact Disc Read Only Memory. CD-ROMs usually come with data already written onto them.

It is possible for users to write data to an optical disk. Once data is written on it with a special utility, many times it can be read from the CD. Hence such CDs are known as 'Write Once Read Many' (WORM) disks. These CDs are known as CD re-recordable (CD-R).

There is a third type of optical disk which can be erased and used to rewrite new information. These are sometimes known as EO (erasable optical) disks or CD-RW (CD rewritable).

Digital Versatile Disks

Digital Versatile Discs are popularly known as DVDs. It is an optical disc storage media format that can be used for data storage, including movies with high video and sound quality. DVDs resemble Compact Discs (CDs) as their physical dimensions are the same but they are encoded in a different format at a much higher density. DVD generally offers more storage capacity (4 GB) as compared to CD.

USB Pen Drives

USB Flash drives are also known as pen drives or thumb drives. They are small, portable and rewritable. They are flash memory data storage devices integrated with a Universal Serial Bus (USB) interface. Figure 4.8 shows a typical USB. They come in different capacities like 2GB, 4GB, 8GB, 16GB, 32GB and 64GB.

Figure 4.8 : USB Pen Drive

Pen drives are most popular as they are very portable, available in various sizes and capacities as well as very efficient for storing the important data. Many instruments like television and MP3 players have USB ports to allow direct use of pen drive. That is, if you have a movie clip or photos in your pen drive, it can be directly attached to the television to see the movies and photos.

Data Representations into Computer Memory

We are familiar with decimal number systems for our routine business. The decimal number system is a positional number system. For example, number 916 is alternatively represented as 900 + 10 + 6. We use ten symbols called digits in the decimal number system, which are 0 to 9. Further, we use alphabets in language such as A…Z. Beside numbers, alphabets and mixture of both of these (called as alphanumeric), special characters such as punctuation marks, operators (<, >, +, -, etc.) and currency symbols ($, £, rupee symbol, etc.) are also used. All these digits, characters and symbols must be arranged in some meaningful way using laws of grammar. This is the main way how we communicate using languages. Besides these, we have sign languages, brail language, body language and facial expression for differently abled people.

Computer, being an electronic device, is not comfortable with these entities. Being mainly an electronic device, it operates on electricity which has only two states 'on' and 'off'. Hence, it requires a special bi-state language having only two symbols; one to represent 'off' and another to represent 'on'. The binary number system is such a bi-state number system that can represent the two states called 'on' and 'off' in an efficient way. Following section represents an introductory concept of a binary number system.

Binary Number System

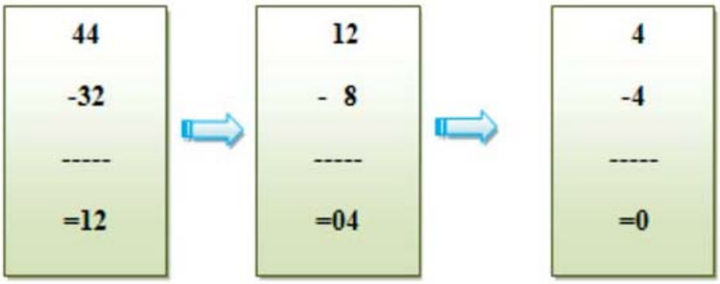
The binary number system has two symbols 0 and 1. Single binary digit is called a bit. A valid binary number example is 101. Since the binary number system uses only two symbols, 102 is not a correct binary number. However, it is a correct decimal number. To quickly identify the given number as binary number, we use suffix B or b. Some representations use 2 as suffix. Hence the binary 101 number is represented as 101_B or 101_b. Alternative representation of the same number is 101_2.

The number 101 represented in a decimal number system can be written as 101_D, 101_d or 101_{10}. This number has meaning 100+00+1. The binary number system also uses such positional notation like the decimal number system. That is, the position of a bit has some significance. The binary number 101_2 has meaning (in decimal) $1*2^2 + 0*2^1 + 1*2^0 = 4 + 0 + 1 = 5$. The binary number can be converted into decimal using this method.

A decimal number is converted into its equivalent binary by successively dividing it by the base 2. An alternative method is to first subtract the largest possible power of two, and keep subtracting the next largest possible power from the remainder, marking 1s in each column where this is possible and 0s where it is not. Here is the example.

Example : Convert 44 into the binary.

Here, the largest possible power of the base 2 is 5. 2^5 is 32. Subtract 32 from the given number. It will leave remainder 12. The immediate power of 2 is 2^4; which is 16. The remainder 12 is less than 16, hence it is not possible to go for subtraction that yields a positive number or zero (non-negative). We then choose power of 2^3; which is 8. It is possible to subtract the number 8 from the last remainder and get a non-negative number. Figure 4.9 shows the complete calculation.



Power of the base 2	2^5=32	2^4=16	2^3=8	2^2=4	2^1=2	2^0=1
Remainder	12	---	4	0	---	---
Subtraction Possible or not	Yes	No	Yes	Yes	No	No
Binary digits	1	0	1	1	0	0

Figure 4.9 : Decimal to Binary Conversion

The final answer is $(101100)_2$.

Conversion of Decimal Number to Binary Number

Let us do the procedure again with another similar method. This time we consider conversion of a decimal 125 number into its equivalent binary number. See Figure 4.10.

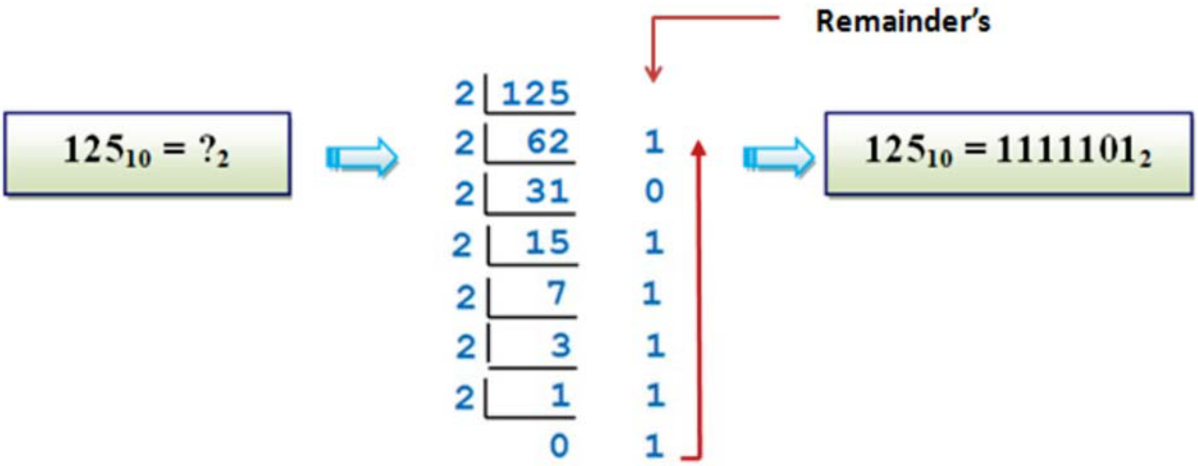


Figure 4.10 : Conversion Example

Unsigned Integer Number Representation

Any unsigned integer number (that is 0 and positive integer number) can be represented into the computer by converting the number into its equivalent binary number. See Figure 4.11 for unsigned integer representation into the computer for the number 5_{10}, which is equivalent to 101_2. **This representation uses 8 bits.**

Number	1	0	1
Position	2nd	1st	0th
Place value	2^2	2^1	2^0
Decimal value	4	0	1

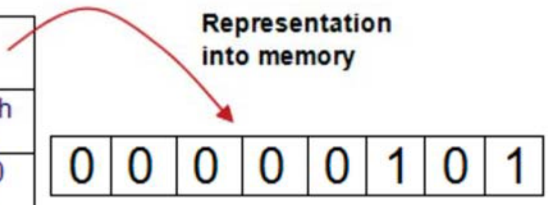


Figure 4.11 : Unsigned Integer Representation

Figure 4.12 illustrates some more examples.

Number in Binary (to be represented into memory)	Sum of Digit $*2^{\text{Place Value}}$	Decimal value
$(0)_2$	$0*2^0$	$=(0)_{10}$
$(1)_2$	$1*2^0$	$=(1)_{10}$
$(11)_2$	$1*2^1 + 1*2^0$	$= 2 + 1$ $=(3)_{10}$
$(110)_2$	$1*2^2 + 1*2^1 + 0*2^0$	$= 4 + 2 + 0$ $=(6)_{10}$
$(10110)_2$	$1*2^4 + 0*2^3 + 1*2^2 + 1*2^1 + 0*2^0$	$= 16 + 0 + 4 + 2 + 0$ $=(22)_{10}$
$(11011)_2$	$1*2^4 + 1*2^3 + 0*2^2 + 1*2^1 + 1*2^0$	$=16 + 8 + 0 + 2 + 1$ $=(27)_{10}$

Figure 4.12 : Examples of Unsigned Integer Representation

Arithmetic operation such as addition, subtraction, etc can be done on such numbers. Here, such simple representations cannot store negative numbers. To store positive as well as negative integer numbers in a computer memory 2's complement method is used.

Signed Integer Representation

To represent 0, positive and negative integers, three different representation schemes are used. These methods are

(1) Sign magnitude method

(2) 1's complement method and

(3) 2's complement method

In a sign magnitude method, a prefix 0 for indicating positive number and a prefix 1 to indicate negative number is used. That is, if number (-5_{10}) is to be stored into memory, first it is converted into its equivalent binary number, which is 101_2. The first bit is 1 and remaining bits are the binary digits representing the number. However, this method has some limitation. For example, the number 0 has two possible representations according to this method, a positive 0 and a negative 0!

1's complement refers to the presentation of a binary number by converting 1's into 0's and vice versa. Here also, one can get two representations of 0 : 00000000 (+0) and 11111111 (-0).

Among methods to represent numbers into computer memory, the 2's complement method is very popular. This system is similar to above mentioned unsigned integer representation except the most significant bit. The most significant bit has negative value. Figure 4.13 show some examples represented using the 2's complement method.

2's complement number	Conversion	Decimal number
$(01000)_2$	$0*2^4 + 1*2^3 + 0*2^2 + 0*2^1 + 0*2^0$ $= 0+8 +0+0+0$	$(8)_{10}$
$(11000)_2$	$-1*2^4 + 1*2^3 + 0*2^2 + 0*2^1 + 0*2^0$ $= -16+8 +0+0+0$	$(-8)_{10}$
$(10000)_2$	$-1*2^4 + 0*2^3 + 0*2^2 + 0*2^1 + 0*2^0$ $= -16+0 +0+0+0$	$(-16)_{10}$
$(10111)_2$	$-1*2^4 + 0*2^3 + 1*2^2 + 1*2^1 + 1*2^0$ $= -16+0 +4+2+1$	$(-9)_{10}$

Figure 4.13 : Conversion of 2's Complement Number into Decimal

The above table shows conversion of a 2's complement number into decimal number. To find a two's complement number from a given decimal number do the following:

(1) Consider the binary representation of a number
(2) Invert the bit of the binary number (make 0 to 1 and vice versa). This is also known as 1's complement number of a given binary number.
(3) Add 1 to it.

Consider the decimal number 9 represented as 9_D. This number can be represented in binary as 01001_B. Changing 0's to 1's and vice versa make the number as 10110_B. Adding 1 to it makes it 10111, which is -9.

It is to be noted that an *n*-bit 2's complement signed integer can represent integers from $-2^{(n-1)}$ to $+2^{(n-1)}-1$. See figure 4.14.

No of binary digits (bits)	Minimum number	Maximum number
8	= $-(2^7)$ =-128	= $+(2^7)-1$ = +127
16	= $-(2^{15})$ = -32,768	= $+(2^{15})-1$ =+32,767
32	= $-(2^{31})$ = -2,147,483,648	= $+(2^{31})-1$ =+2,147,483,647

Figure 4.14 : Range of Numbers

Floating Point Number Representation

To represent fractional number, floating point number representation is used. The IEEE 32 bit single precision method is commonly used to represent a real number. Here, IEEE represents Institute of Electrical and Electronics Engineers, which is the world's largest professional association dedicated to advancing technological innovation and excellence for the benefit of humanity (www.ieee.org).

According to the method, representation of a given number is divided into three parts as shown in figure 4.15.

Sign(S)	Exponent(E)	Fraction(F)
31	30-------------------23	22-----------------------------0
← 1 →	← 8 →	← 23 →

Figure 4.15 : IEEE 32 bit Single Precision Floating Point Number

The three parts are given below :

(a) The most significant bit is the *sign bit* (S), with 0 for negative numbers and 1 for positive numbers.

(b) The following 8 bits represent *exponent* (E).

(c) The remaining 23 bits represents *fraction* (F).

Consider the number shown in figure 4.16, the sign bit represents the sign of the number. If S=0 then the number is positive. If S=1 then the number is negative. In this example S=1, hence it is a negative number.

1 1000 0001 011 0000 0000 0000 0000 0000.

Here

S = 1 → single bit for sign

E = 1000 0001 → 8 bits exponent

F = 011 0000 0000 0000 0000 0000 → fraction in 23 bits

Figure 4.16 : Example of a Number in IEEE Format

The exponent given here is $1000\ 0001_B$. The decimal equivalent of this number is 129 or 129_D. In a normalized form the actual exponent is E-127, where E is exponent given, hence it is also called excess 127 notation. This is required to represent positive and negative number as exponent. That is, here actual exponent is $129-127=2_D$.

Similarly, the fraction is presented in a normalized form with a hidden 1.F form. The fraction given here is $011\ 0000\ 0000\ 0000\ 0000\ 0000_B$. That is, the actual fraction is $1.\ 011\ 0000\ 0000\ 0000\ 0000\ 0000_B$. The decimal equivalent for the number is 1.375 or 1.375_D.

Putting all these three components together, we have a number as $-1.375 \times 2^2 = -5.5_D$.

Consider another example having representations :

1 01111110 100 0000 0000 0000 0000 0000.

Then the equivalent representation in decimal can be calculated as follows :

Sign bit S = 1 indicates negative number

$E = 0111\ 1110_B = 126_D$ (in normalized form)

Fraction is 1.1_B (with an implicit leading 1) = $1 + 2^{\wedge -1} = 1.5_D$

The number is $-1.5 \times 2^{\wedge(126-127)} = -0.75_D$

Character Representation

In computer memory, characters are represented using bit patterns. Group of 7, 8, 16 or 32 bits can be used to represent each character. The rules that determine such bit patterns in a specific length are known as coding schemes. Historically 7 bit American Standard Code for Information Interchange (ASCII) code, 8 bit American National Standards Institute (ANSI) code and Extended Binary Coded Decimal Interchange Code (EBCDIC) were used. These coding schemes represent characters into 7 or 8 bit binary code. Table 4.3 illustrates ASCII representation of selected characters.

Symbol	Decimal	Binary
7	55	00110111
8	56	00111000
9	57	00111001
:	58	00111010
;	59	00111011
<	60	00111100
=	61	00111101
>	62	00111110
?	63	00111111
@	64	01000000
A	65	01000001
B	66	01000010
C	67	01000011

Table 4.3 : Characters Represented into ASCII

One can represent maximum 256 possible patterns using the size of 8 bits, where each pattern represents a specific character. Hence, we may represent limited number of characters. Further, these character schemes do not represent all the characters in all the languages in uniform format. Presently, Unicode scheme is used to represent characters into the computer memory. Unicode provides universal and efficient character presentations and hence evolved as modern character representation scheme. Unicode scheme is developed and maintained by a non-profit organization called Unicode consortium (www.unicode.org). Unicode is also compatible with other coding schemes like ASCII. Unicode use either 16 or 32 bits to represent a character. Unicode has capability to represent characters from all the major languages across the world. The 16 bit Unicode scheme allows 65,536 (64K) unique patterns. That is, it can represent 65,536 characters uniquely. Further, 44,949 more characters were added into the scheme in May 2001. The added characters were from Chinese, Japanese, and Korean language and culture. Presently, the Unicode latest standard (32 bits) can represent more than 1 lakh characters in unique pattern. Table 4.4 illustrates some sample Unicode characters formation.

Unicode	Character	Description
U+0030	0	Digit Zero
U+0031	1	Digit One
U+0032	2	Digit Two
U+003A	:	Colon
U+003B	;	Semicolon
U+003C	<	Less-than sign
U+003D	=	Equal sign
U+003E	>	Greater-than sign
U+003F	?	Question mark
U+0040	@	At sign
U+0041	A	Latin Capital letter A
U+0042	B	Latin Capital letter B

Table 4.4 : Unicode Character Formation

Image Representation into Computer Memory

Image represented in a computer memory is called digital image. The reason behind this is that the image is ultimately converted into sequence of 0's and 1's for its possible representation into the computer memory.

One way to describe an image using digits is to describe its contents using position and size of geometric forms and shapes such as lines, curves, rectangles and circles. Such representation is called vector image representation. A vector image can be easily enlarged or shrunk without affecting the quality of the image. Vector images are the preferred way to represent fonts, logos and many illustrations.

Another way to represent an image into computer memory is dividing the image into fix number of rows and columns. Each cell (intersection of a row and a column) is known as pixel (picture cell). Each pixel represents a value that represents the brightness of a given color at any specific point. If you divide the image using more number of rows and columns, very fine information about the image can be stored and hence quality of the image increases. The set of pixels, normally in the form of two dimensional array, is stored in computer memory as a raster image or raster map. To improve quality of an image, we really need to store high amount of data into computer memory.

An image that is 2048 pixels in width and 1536 pixels in height has a total of 2048×1536 = 3,145,728 pixels or 3.1 megapixels. One could refer to it as 2048 by 1536 or a 3.1 megapixel image. You might have observed some mobile phones or digital cameras with specification such as 3.1 mega pixel. That means, the image taken by the camera, has 2048×1536 resolution. The term resolution is often used for a pixel count in digital image.

Many times it is difficult to deal with such a bundle of data. An image takes a significant amount of memory to store all its pixels. And, we must remember that we may have to store number of images into computer memory. This problem becomes even harder to manage when we try to send the bunch of images via computer network. To avoid such memory management and image transferring problem, images are often stored and transferred in compressed forms.

For raster images following formats are popular :

- .bmp (Bit Map Image),
- .jpg (Joint Photographic Experts Group),
- .png (Portable Network Graphics),
- .gif (Graphics Interchange Format), and
- .tiff (Tagged Image File Format).

Just like images, audio and video information is also represented as digital information into computer memory. Computer represents sound as binary numbers. For this, parameters such as frequency and resolution are considered. The sound/audio files have formats like .Wav (Waveform audio file format), .mp3 (moving picture experts group), and .WMA (Windows Media Audio). Digital video is a type of digital recording system that works by using a digital rather than an analog video signal. Digital video consists of sequence of digital images displayed in continuous fashion at a constant rate. These images are identified as frames. In a second, typically more than 45 frames must have to be passed to generate effect of continuous scene. However, early silent films had frames up to 25-30 per second. Popular video file formats are .flv (flash video format), .avi (audio video interleave), .wmv (windows media video) and .mp4 (moving picture experts group) format.

Summary

In this chapter, we have learnt about how computer can store data and instructions. Basic units of computer memory such as bit and bytes, categories of memory such as primary and secondary memories, hard disks, compact discs and digital versatile disks are also illustrated here. We also learnt how to represent information such as integers, real numbers, characters and other multi-media information into computer memory.

EXERCISE

1. What is computer memory ?
2. What is primary memory ?
3. What is secondary memory ?
4. Define bit. What are the symbols used to represent a bit ?
5. What are the measurement units for computer memory ? What is the relationship between these units ?
6. Describe the following terms in one or two sentences :

   (a) RAM (b) ROM (c) PROM

   (d) EPROM (e) EEPROM (f) FIFO

   (g) LIFO
7. What is sequential access ?
8. What is RAM ? How many types of RAM exist ? Explain each in one line.
9. What is ROM ? Where ROM is useful ?
10. Distinguish between RAM and ROM.
11. What is cache ? For what purpose is it useful ?
12. List any three secondary storage devices. Explain any one in brief.
13. Explain how numbers are represented into computer memory ?
14. Write a short note on IEEE floating point number representation.
15. How images are represented into computer memory ?
16. **Choose the most appropriate option from those given below :**

    (1) What is an alternative name of a primary memory ?

    (a) Volatile (b) Permanent

    (c) Auxiliary (d) Any of these

    (2) For what amount of time does a secondary memory retain its content ?

    (a) Short duration (b) Long time

    (c) Never (d) Any of these

    (3) Which of the following is the unit of computer memory ?

    (a) Bit (b) Pit

    (c) Chit (d) Kit

    (4) How many bits form a byte ?

    (a) 4 (b) 8

    (c) 16 (d) 32

(5) Which of the following is a correct example of a LIFO ?

(a) A queue of people (b) Cars waiting for service

(c) Pile (tray) of paper (d) Jobs waiting for services

(6) Which of the following mechanism is used to erase content of An EPROM ?

(a) ultraviolet light (b) electric signal

(c) laser technology (d) magnetic field

(7) Which of the following type of memory is used by pen drives ?

(a) RAM (b) PROM

(c) EEPROM (d) Any of these

(8) Which of the following is a small and high speed memory within the computer central processing unit ?

(a) Secondary (b) Auxiliary

(c) Cache (d) ROM

(9) Which of the following is not a secondary storage device ?

(a) Cache memory (b) Compact disks

(c) DVDs (d) Pen drives

(10) Which of the following number system is most suitable for basic computer data representation into machine readable form ?

(a) Binary (b) Octal

(c) Ternary (d) Hexadecimal

(11) Which of the following number systems has 2 symbols 0 and 1 ?

(a) Decimal (b) Binary

(c) Hexadecimal (d) Octal

(12) Which of the following method is used to represent an integer number into computer memory ?

(a) Sign magnitude method (b) 1's complement method

(c) 2's complement method (d) All of these

(13) Which of the following method is used to represent characters into computer memory ?

(a) ASCII (b) Unicode

(c) EBCDIC (d) All of these

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