Activity

1 Complete this table with the names of application software that has the same function on a PC or laptop and on a mobile device, a phone or tablet. The first two have been added for you but add your own ideas.

Function	PC or laptop	Mobile device
Web browser		
Image editing and creation		

2 Do you use any cloud computing software? Can you think of any disadvantages of this type of software? Think about the following:
- security and privacy
- connectivity
- data charges

3 Do we still need PCs? Make a list of tasks that are better done on a PC than on a mobile device. Give a reason for each.

HELPFUL NOTES

System software is designed to run and maintain a computer system.

System software

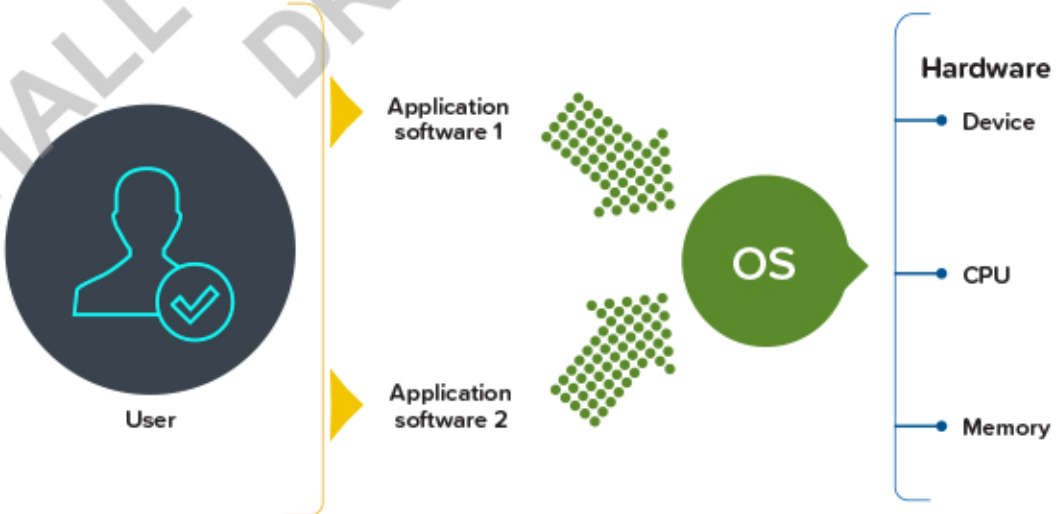
System software is designed to run a computer's hardware and application programs. It acts as an interface between the hardware and the software. System software is not normally used directly by the user, whereas application software is.

Operating systems (OS)

An operating system is software that manages computer hardware and software resources, and provides common services for computer programs. An operating system also provides the user interface, which allows interactions between the system and the user.

DEFINITION

User interface: Allows the user to interact with the computer system in a familiar layout allowing interaction with the input devices and software.



DEFINITION

Logic gates: the basic units of a digit circuit that control the flow of electronic signals.

10.1 Logic gates

Logic gates are the basic building units of any digital circuit. Today, these circuits are used in almost every computer system. From elevators, to washing machines, logic gates are used all around you.

▲ Digital circuit used to open electronic door.

This chapter will explore the types and function of common logic gates.

There are a number of different types of logic gate, with different logic rules. The combination of several logic gates forms a circuit, which allows for the design and performance in modern computers. The gates receive binary data, apply a Boolean operation, and then output a binary result.

Boolean operations

The word 'Boolean' comes from Boolean algebra, which is the basis of computer arithmetic and especially logic gates. There are only two Boolean values: True and False. They have equivalents in normal language and in binary notation.

Boolean expressions can compare data of any type as long as both parts of the expression have the same data. In computer science, Boolean expressions can be used in programming and produce Boolean values when evaluated. Boolean values are either true or false:

Boolean Value	Binary Value	Synonyms		
True	1	On	Yes	Positive
False	0	Off	No	Negative

There are also three logical operators: NOT, AND, and OR. The Boolean Operators for these are AND '•', OR '+', and NOT '¯', which is written above the letter.

$\bar{A}$ means NOT A

A • B means A AND B

A + B means A OR B

Logic gates, use both Boolean values and operators.

WORD ALERT

Combination: a joining of different parts or qualities

Arithmetic: Use of numbers to calculate an outcome

Equivalent: The same equal meaning

LINK

Exercise 1 in the Workbook.

Worked Example

We use Boolean logic all the time. Look at this situation using Boolean operators:

You have decided that you will do extra study if you are falling behind at school. You also decide that you will do extra study even when you are not behind if your friend asks you to study together. Express this using Boolean operators.

Solution

To express this formally and logically we need two pieces of information to make our decision and another piece to represent the result of the decision. We can name our information like this:

Information needed to make decision

(behind at school) = TRUE if fall behind. If not, FALSE.

(friend asks you to study) = TRUE if friend asks you to study. If not, FALSE.

Result

(do extra study) = TRUE if we decide to do extra study. If not, FALSE.

Our logical expression is then:

(do extra study) = (behind at school) OR (NOT (behind at school)) AND (friend asks you to study)

This expression uses the three Boolean operators: NOT, AND, OR.

WORD ALERT

Formally: Officially / Explicitly

Activity

1 Write a logical expression like the example above for this given scenario.
There are two methods of getting to your part time job on time. You can get the bus but only if wake up before 9.00am. If you wake up after this time you will need to ask your parents to take you in the car. If you wake up before 9.00am but your parents offer to take you, then you will always say yes as it is easier.

2 Draw the Boolean Algebra symbols for the following:

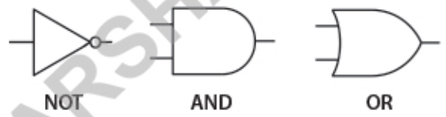
a) A NOT B

b) A AND B

c) A OR B

Types of logic gate

There are three basic types of logic gate that will be examined in this chapter: NOT, AND, and OR.



The left side of the logic gate is referred to as the input and the right side as the output.

We can use a truth table to show the function of the logic gate. Each of the logic gates has a different truth table. These truth tables display all possible input combinations and the correct output.

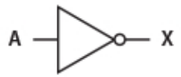
HELPFUL NOTES

In all logic gates except the NOT gate, there are two inputs. The inputs or outputs have two possible states: a value of 1 or a value of 0.

WORD ALERT

Referred: Denoted / Identified

NOT gate



The NOT gate takes a single input, A in the diagram above, and always produces the opposite of that input in a single output, X.

Here is the truth table for the NOT gate above. It displays all possible combinations of inputs and the corresponding outputs for the NOT gate. There are only two possible outputs for a NOT gate: 0 and 1.

Input	Output
A	X
0	1
1	0

Besides constructing truth tables, we can describe each gate using logic notation and Boolean algebra. In this case the output is as follows:

Logic notation: X = NOT A

Boolean algebra: $X = \bar{A}$

AND gate

The AND gate takes the inputs A and B and produces the output, X. If both inputs are 1, then the output will be 1, but otherwise the output will be 0.

Here is the truth table for the AND gate above.

Input		Output
A	B	X
0	0	0
0	1	0
1	0	0
1	1	1

Logic notation: X = A AND B

Boolean algebra: X = A·B

A and B show all possible combinations of inputs, so there are a total of four possible output states.

OR gate

The OR gate takes two inputs, A and B, and produces output X. If either or both inputs is 1, the output will be 1.

DEFINITION

Truth tables are used to represent the Boolean expression of a logic gate or logic circuit.

ENRICHMENT

The total number of possible combinations can be obtained from the formula $C = 2^n$, where C is the number of total possible combinations and n is the number of inputs.

For example, if there are three inputs, A, B and C, the total possible combination of inputs is $C = 2^3 = 8$.

REFLECT

If someone asks you, 'Do you want a soda or some water?', or 'Do want to watch TV or play a video game?', you can't answer 'Both, please'. If you could have both that would be an inclusive use of OR. Is the OR gate inclusive or exclusive?

Here is the truth table for the OR gate above:

Input		Output
A	B	X
0	0	0
0	1	0
1	0	0
1	1	1

Logic notation: X = A OR B

Boolean algebra: X = A + B

Out of the four possible output states, the only time output X will be 0 is when both the inputs A and B are 0.

Worked Example

A security light outside a house comes on after 6.00pm or if it is dark. Make a table showing the operation in normal language with corresponding Boolean and binary values. Make the resulting truth table and choose the logic gate that will make this happen.

Solution

We have to state the conditions under which the light will come on:
if it is after 6.00pm
if it is dark

Then we convert these into the Boolean values 'True' and 'False':
it is after 6.00pm = Yes/True/Positive
if it is dark = Yes/True/Positive

Next we add the binary values:

It is after 6.00pm	Yes	True	Positive	1
It is dark	Yes	True	Positive	1

Then we make the truth table. The inputs are 'it is after 6.00pm and 'it is dark':

Inputs	
It is after 6.00pm	It is dark

The light coming on is the output:

Inputs		Output
It is after 6.00pm	It is dark	the light comes on

Remember that the light will come on if either of the conditions is true:

Inputs		Output
It is after 6.00pm	It is dark	the light comes on

WORD ALERT

Condition: The state of something in relation to its appearance, quality, or working order.

QUICK CHECK

In all logic gates except the NOT gate, there are two inputs. The inputs or outputs have two possible states. What are they?

And the logic statement would be:

X = (A AND B) AND (NOT C)

And the truth table would be as follows::

Input			Intermediate Output		Output
A	B	C	P= (A AND B)	Q= (NOT C)	X
0	0	0	0	1	0
0	0	1	0	0	0
0	1	0	0	1	0
0	1	1	0	0	0
1	0	0	0	1	0
1	0	1	0	0	0
1	1	0	1	1	1
1	1	1	1	0	0

Let's Map It

LOGIC GATES

Logic gates have logic states given by:

Boolean Values

Boolean value	Binary value	Synonyms		
True	1	On	Yes	Positive
False	0	Off	No	Negative

which are used in truth tables:

Truth tables

Truth tables are used to represent the Boolean expression of a logic gate or logic circuit.

Inputs		Output
A	B	X
0	0	0
0	1	1
1	0	1
1	1	1

and in the different types of logic gates

COMBINING LOGIC GATES

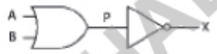
Using Boolean Algebra:

Boolean algebra

$\overline{A}$	NOT A	$A+B$	A NAND B
$A+B$	A and B	$\overline{A+B}$	A NOR B
$\overline{A+B}$	A OR B	$A \oplus B$	A XOR B

and by combining different logic gates

Combining logic gates



INPUT		INTERMEDIATE OUTPUT	OUTPUT
A	B	P	X
0	0	0	1
0	1	0	1
1	0	0	1
1	1	1	0

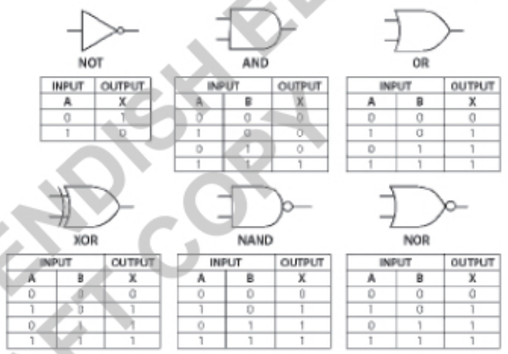
We can write logic statements for logic circuits

Logic statements

Break down the statements: always start with the output

X = (A AND B) OR C

Types of gates



All have 2 inputs except for 'NOT' gate

Examples of logic circuits used in the real world

- Security alarms
- Elevators
- Electrical circuits eg light switches
- Bank vaults