Design Methodology

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Structure vs Behavior:

We define the "structure" of a system as the abstract graph consisting of its block diagram with no functional information.

A structural description merely names components and defines their interconnection. A behavioral description, on the other hand, enables one to determine for any given input signal a to the system, the corresponding output f(a). We define the function f to be the "behavior" of the system.

Truth table: The tabulation of all possible combinations of input-output values is called a "truth table".

Hardware description languages:

A Hardware Description Language (HDL), a format that resembles a high-level programming language such as Ada or C. The construction of such description languages can be traced back at least as far as Babbage.

Hardware description languages such as VHDL have several advantages. They can provide precise, technology-independent descriptions of digital circuits at various levels of abstraction, primarily the gate and register levels. Consequently, they are widely used for documentation

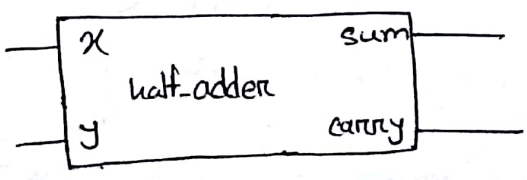
purpose. Like programming languages, HDLs can be processed by computers, and so are suitable for use with computer-aided design (CAD) programs which, as discussed later, play an important role in the design process.

VHDL Description of a half adder:

A VHDL description has two main parts: an "entity" part and an "architecture" part. The entity part is a formal statement of the system's structure at the highest level, that is, as a single component. It describes the system's "interface", which is the "face" presented to external devices but says nothing about the system's behavior or its internal structure. In this example the entity statement gives the half-adder's formal name "half-adder" and the names assigned to its input-output (IO) signals; IO signals are reffered to in VHDL by their connection terminals or ports. Input and outputs are:

Inputs		Outputs	
x	y	sum	carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

(i)



(ii)

Combinational Logic :

A "combinational function" also referred to as a "logic" or a "Boolean" function, is a mapping from the set of 2^n input combinations of n binary variables onto the output values 0 and 1. Such a function is denoted by $z(x_1, x_2, \ldots, x_n)$ or simply by z. The function z can be defined by a truth table, which specifies for every input combination $(x_1, x_2, \ldots, x_n)$ the corresponding value of $z(x_1, x_2, \ldots, x_n)$. Figure shows the truth table for a pair of three-variable functions, $S_0(x_0, y_0, C_{-1})$ and $C_0(x_0, y_0, C_{-1})$, which are the sum and carry outputs, respectively, of a logic circuit called a half-adder. This useful logic circuit computes the numerical sum of its three input bits using binary (base 2) arithmetic :

$$C_0 S_0 = x_0 \text{ plus } y_0 \text{ plus } C_{-1}.$$

Inputs			Outputs	
x_0	y_0	C_{-1}	C_0	S_0
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

⊞Design of a Fixed-Point Binary Multiplier:

Fixed-point multiplication is often implemented in computers by a binary version of the manual multiplication algorithm for decimal numbers based on repeated addition and shifting. Consider the task of multiplying two 8-bit binary functions $X = x_0x_1x_2x_3x_4x_5x_6x_7$ and $Y = y_0y_1y_2y_3y_4y_5y_6y_7$ to form the product $P = X \times Y$. Each number is assumed to be in sign-magnitude form, where the left most bit (with subscript 0) of the number denotes its sign: 0 for positive and 1 for negative. The remaining seven bits represent the number's magnitude. Note that for functions, it is convenient to index the numbers from left to right, so that bit x_i has weight 2^{-i}. Hence when $x_0 = 0$, $X = x_0x_1x_2x_3x_4x_5x_6x_7$ the positive number N given by

$$N = x_1 2^{-1} + x_2 2^{-2} + x_3 2^{-3} + x_4 2^{-4} + x_5 2^{-5} + x_6 2^{-6} + x_7 2^{-7}$$

when $x_0 = 1$, X denotes $-N$.

The multiplication algorithm that we will implement first multiplies the magnitude parts X_M and Y_M of X and Y. Thus:

$$P_M := X_M \times Y_M$$

where $P_M = P_1P_2 \cdots P_{14}$ is the magnitude of the product P.

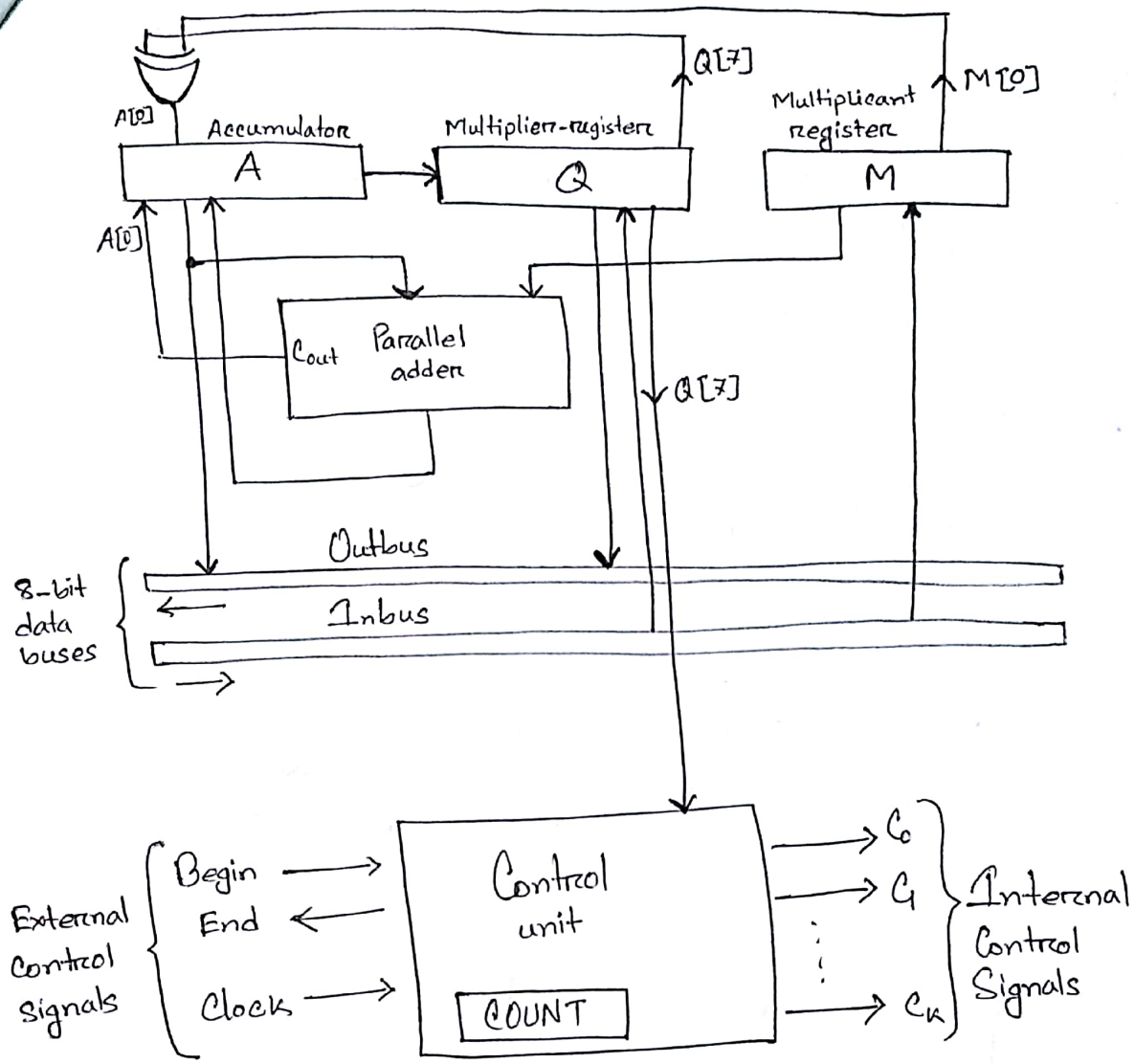


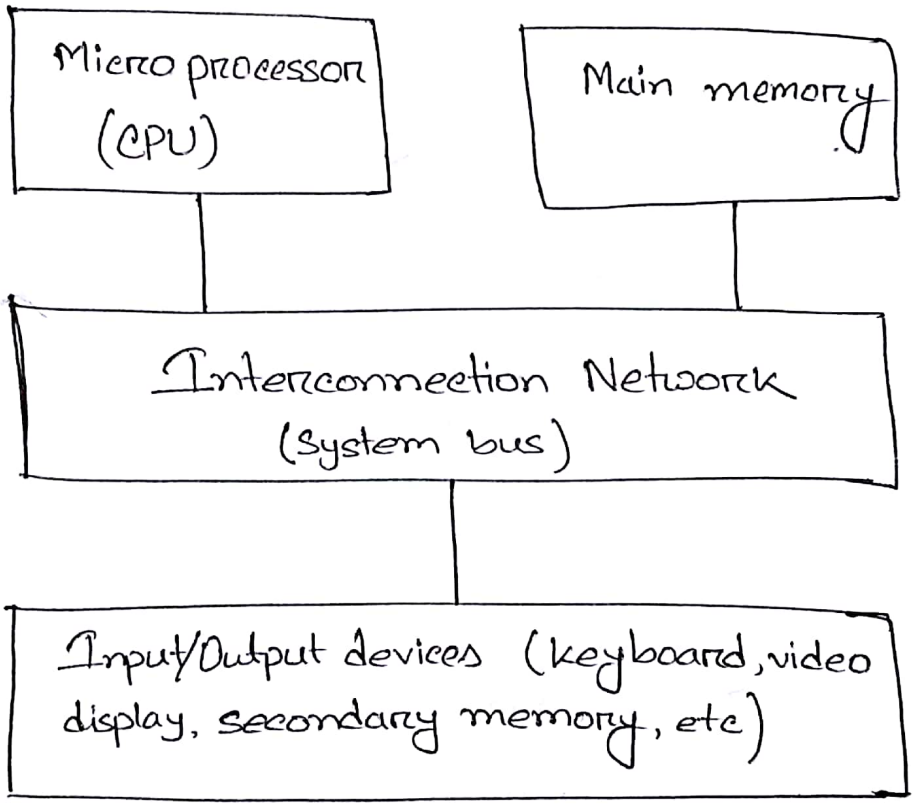
fig: Block diagram of an 8-bit binary multiplier multiplier8.

Central Processing Unit:

We define a CPU to be a general-purpose, instruction-set processor that has overall responsibility for program interpretation and execution in a computer system. The qualifier general-purpose distinguishes CPUs from other, more specilized processors, such as IO processors (IOPs), whose functions are restricted.

Major components of a computer system:

The CPU's datapath (E-unit) has the arithmetic-logic circuits that execute most instructions; it also has a set of registers for temporary data storage. The CPU manages a system bus, which is the main communication link among the CPU-cache subsystem, main memory, and IO devices.



IO devices:

Input-Output devices are the mean by which a computer communicates with the outside world. A primary function of IO devices is to act as data transducers, that is, to convert information from one physical representation to another. Unlike processors, IO devices do not alter the information content or meaning of the data on which they act. Since data is transferred and processed within a computer system in the form of digital electrical signals, input (output) devices transform other forms of information to (from) digital signals.

Must need requirement of a Computer:

The common approach to design to take a "prototype design" of known performance and modify it where necessary to accomodate new technologies or meet ~~new~~ new performance requirements. The performance specifications usually take the following form:

(i) The computer should be capable of executing a instructions of type b per second.

(ii) The computer should be able to support c memory or IO devices of type d.

(iii) The computer should be compatible with computers of type e.

(iv) The total cost of the system should not exceed f.