

## Asynchronous Data Transfer :

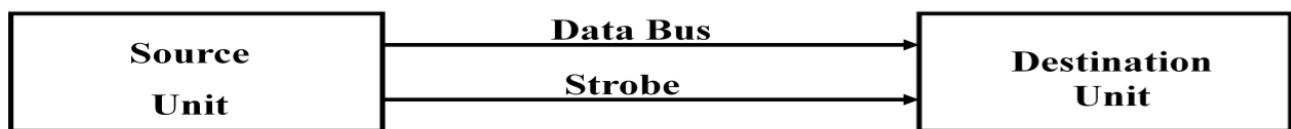
This Scheme is used when speed of I/O devices do not match with microprocessor, and timing characteristics of I/O devices is not predictable. In this method, process initiates the device and check its status. As a result, CPU has to wait till I/O device is ready to transfer data. When device is ready CPU issues instruction for I/O transfer. In this method two types of techniques are used based on signals before data transfer.

i. Strobe Control ii. Handshaking

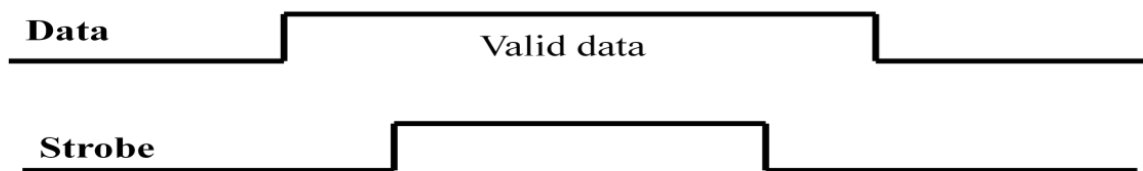
### Strobe Signal :

The strobe control method of Asynchronous data transfer employs a single control line to time each transfer. The strobe may be activated by either the source or the destination unit.

#### Data Transfer Initiated by Source Unit:



(a) Block Diagram



(b) Timing Diagram

#### Source-Initiated strobe for Data Transfer

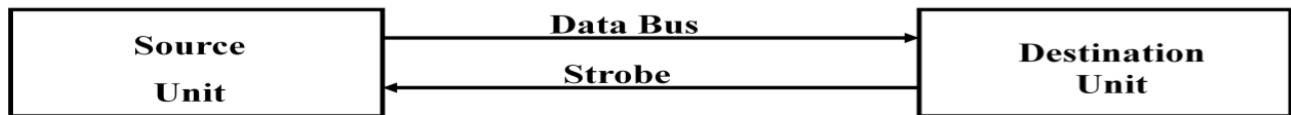
In the block diagram fig. (a), the data bus carries the binary information from source to destination unit. Typically, the bus has multiple lines to transfer an entire byte or word. The strobe is a single line that informs the destination unit when a valid data word is available.

The timing diagram fig. (b) the source unit first places the data on the data bus. The information on the data bus and strobe signal remain in the active state to allow the destination unit to receive the data.

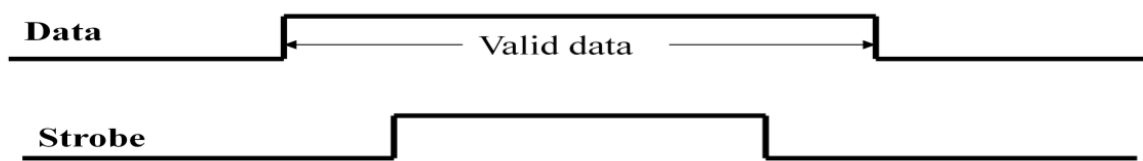
#### Data Transfer Initiated by Destination Unit:

In this method, the destination unit activates the strobe pulse, to informing the source to provide the data. The source will respond by placing the requested binary information on the data bus.

The data must be valid and remain in the bus long enough for the destination unit to accept it. When accepted the destination unit then disables the strobe and the source unit removes the data from the bus.



(a) Block Diagram



(b) Timing Diagram

#### Destination-Initiated strobe for Data Transfer

Disadvantage of Strobe Signal :

The disadvantage of the strobe method is that, the source unit initiates the transfer has no way of knowing whether the destination unit has actually received the data item that was placed in the bus. Similarly, a destination unit that initiates the transfer has no way of knowing whether the source unit has actually placed the data on bus. The Handshaking method solves this problem.

Handshaking:

The handshaking method solves the problem of strobe method by introducing a second control signal that provides a reply to the unit that initiates the transfer.

Principle of Handshaking:

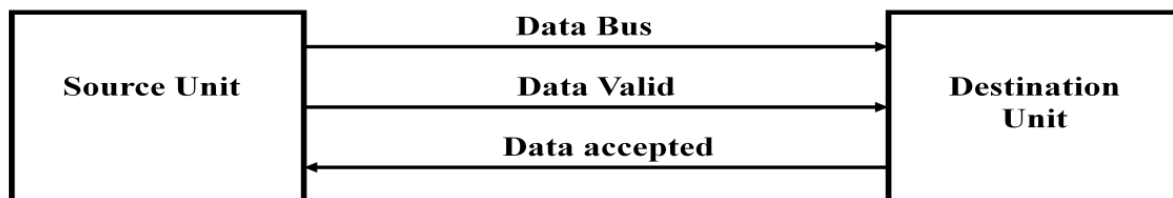
The basic principle of the two-wire handshaking method of data transfer is as follow:

One control line is in the same direction as the data flows in the bus from the source to destination. It is used by source unit to inform the destination unit whether there a valid data in the bus. The other control line is in the

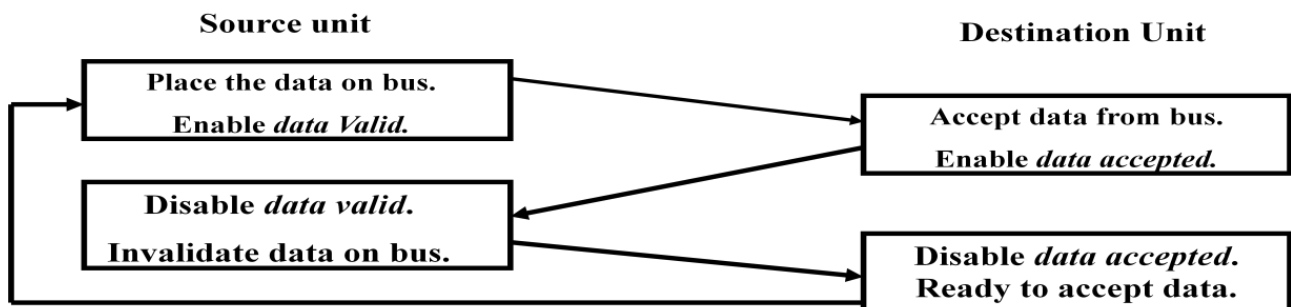
other direction from the destination to the source. It is used by the destination unit to inform the source whether it can accept the data. The sequence of control during the transfer depends on the unit that initiates the transfer.

### Source Initiated Transfer using Handshaking:

The sequence of events shows four possible states that the system can be at any given time. The source unit initiates the transfer by placing the data on the bus and enabling its data valid signal. The data accepted signal is activated by the destination unit after it accepts the data from the bus. The source unit then disables its data accepted signal and the system goes into its initial state.



(a) Block Diagram

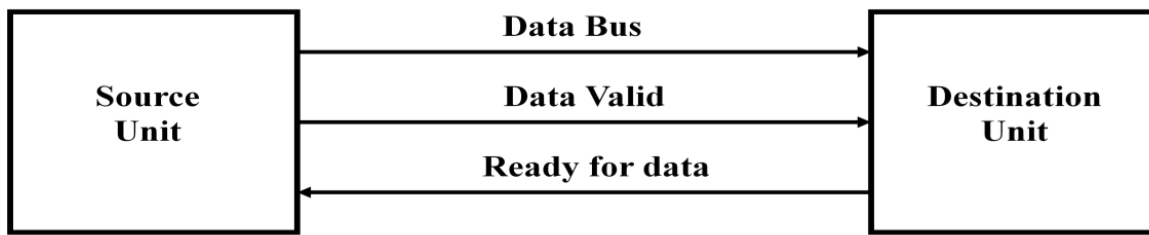


(b) Sequence of events

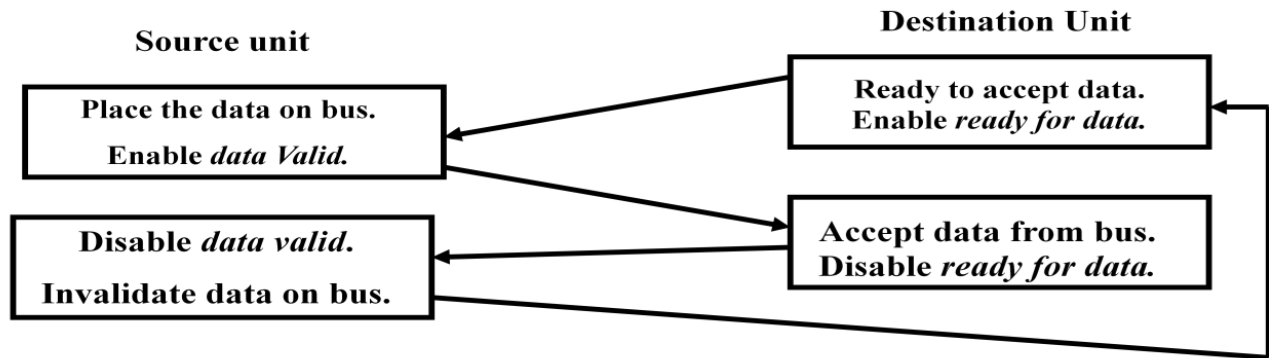
### Destination Initiated Transfer Using Handshaking:

The name of the signal generated by the destination unit has been changed to ready for data to reflect its new meaning. The source unit in this case does not place data on the bus until after it receives the ready for data signal from the destination unit. From there on, the handshaking procedure follows the same pattern as in the source initiated case.

The only difference between the Source Initiated and the Destination Initiated transfer is in their choice of Initial state.



(a) Block Diagram



(b) Sequence of events

### Destination-Initiated transfer using Handshaking

Advantage of the Handshaking method:

- The Handshaking scheme provides degree of flexibility and reliability because the successful completion of data transfer relies on active participation by both units.
- If any of one unit is faulty, the data transfer will not be completed. Such an error can be detected by means of a Timeout mechanism which provides an alarm if the data is not completed within time.

### Modes of Data Transfer :

Transfer of data is required between CPU and peripherals or memory or sometimes between any two devices or units of your computer system. To transfer a data from one unit to another one should be sure that both units have proper connection and at the time of data transfer the receiving unit is not busy. This data transfer with the computer is Internal Operation.

All the internal operations in a digital system are synchronized by means of clock pulses supplied by a common clock pulse Generator. The data transfer can be

- i. Synchronous or
- ii. Asynchronous

When both the transmitting and receiving units use same clock pulse then such a data transfer is called Synchronous process. On the other hand, if there is not concept of clock pulses

and the sender operates at different moment than the receiver then such a data transfer is called Asynchronous data transfer.

The data transfer can be handled by various modes. some of the modes use CPU as an intermediate path, others transfer the data directly to and from the memory unit and this can be handled by 3 following ways:

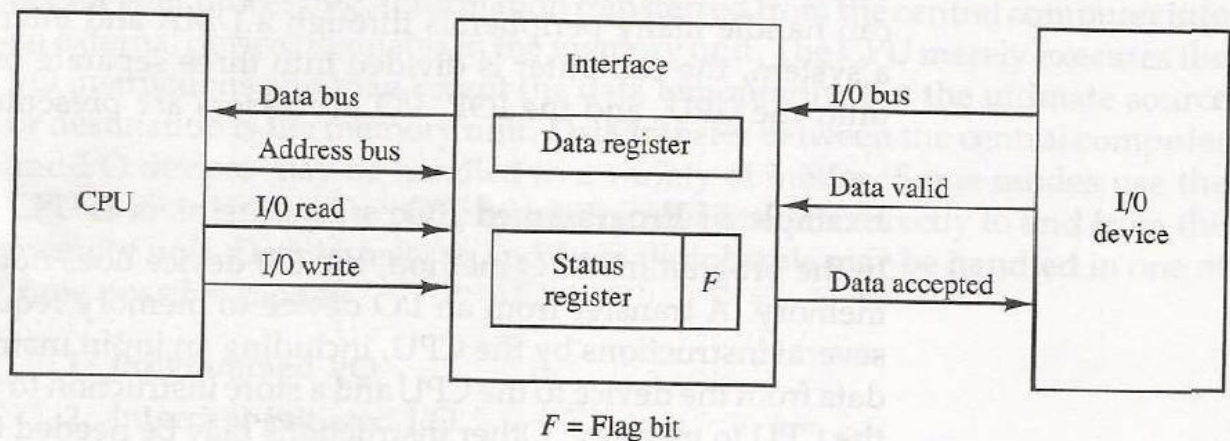
- i. Programmed I/O
- ii. Interrupt-Initiated I/O
- iii. Direct Memory Access (DMA)

### **Programmed I/O Mode:**

In this mode of data transfer the operations are the results in I/O instructions which is a part of computer program. Each data transfer is initiated by a instruction in the program. Normally the transfer is from a CPU register to peripheral device or vice-versa.

Once the data is initiated the CPU starts monitoring the interface to see when next transfer can made. The instructions of the program keep close tabs on everything that takes place in the interface unit and the I/O devices.

Figure Data transfer from I/O device to CPU.



- The transfer of data requires three instructions:

1. Read the status register.
2. Check the status of the flag bit and branch to step 1 if not set or to step 3 if set.
3. Read the data register.

In this technique CPU is responsible for executing data from the memory for output and storing data in memory for executing of Programmed I/O as shown in Flowchart-:

Drawback of the Programmed I/O :

The main drawback of the Program Initiated I/O was that the CPU has to monitor the units all the times when the program is executing. Thus the CPU stays in a program loop until the I/O unit indicates that it is ready for data transfer. This is a time consuming process and the CPU time is wasted a lot in keeping an eye to the executing of program.

To remove this problem an Interrupt facility and special commands are used.

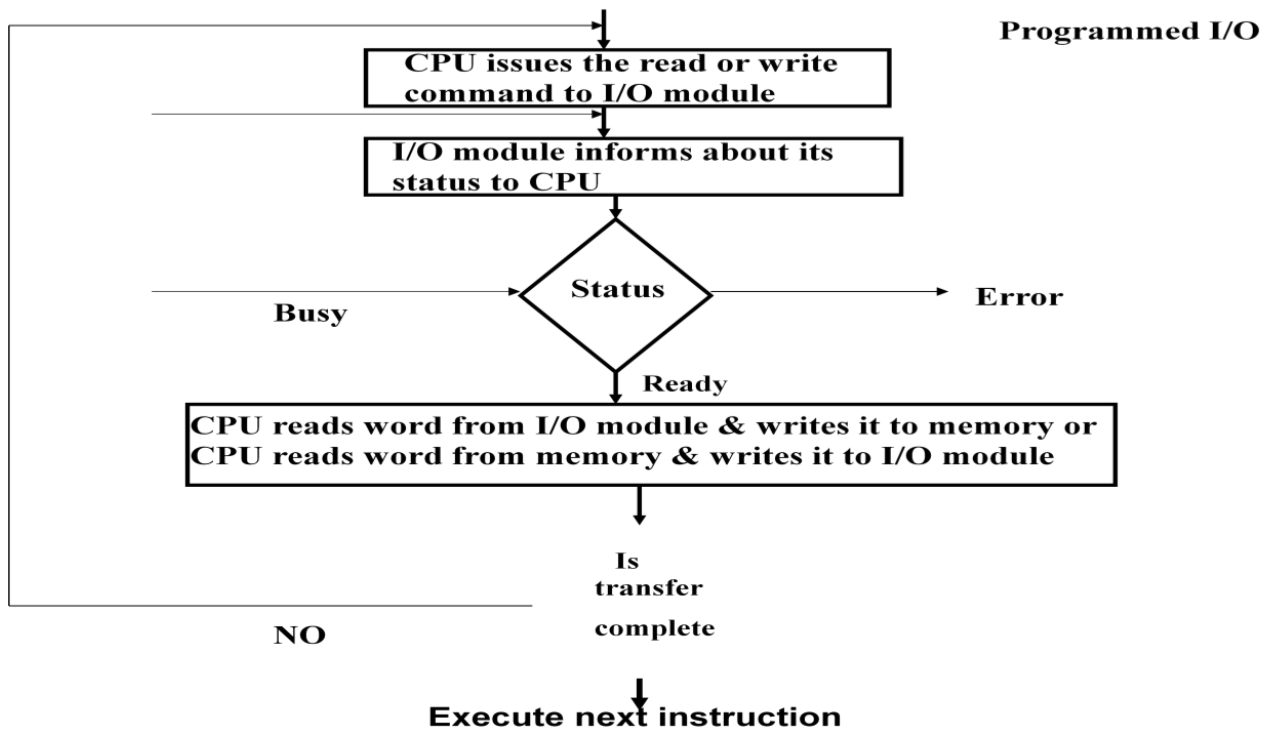
Interrupt-Initiated I/O :

In this method an interrupt facility an interrupt command is used to inform the device about the start and end of transfer. In the meantime the CPU executes other program. When the interface determines that the device is ready for data transfer it generates an Interrupt Request and sends it to the computer.

When the CPU receives such an signal, it temporarily stops the execution of the program and branches to a service program to process the I/O transfer and after completing it returns back to task, what it was originally performing.

- In this type of IO, computer does not check the flag. It continue to perform its task.

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## **Interrupt-Initiated I/O :**

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- Whenever any device wants the attention, it sends the interrupt signal to the CPU.
  
- CPU then deviates from what it was doing, stores the return address from PC and branches to the address of the subroutine.
  
- There are two ways of choosing the branch address:
  - Vectored Interrupt
  
  - Non-vectored Interrupt
  
- In vectored interrupt the source that interrupts the CPU provides the branch information. This information is called interrupt vectored.
  
- In non-vectored interrupt, the branch address is assigned to the fixed address in the memory.



## Priority Interrupt:

- There are number of IO devices attached to the computer.
- They are all capable of generating the interrupt.
- When the interrupt is generated from more than one device, priority interrupt system is used to determine which device is to be serviced first.
- Devices with high speed transfer are given higher priority and slow devices are given lower priority.
- Establishing the priority can be done in two ways:
- Using Software
- Using Hardware
- A pooling procedure is used to identify highest priority in software means.

### Polling Procedure :

- There is one common branch address for all interrupts.
- Branch address contain the code that polls the interrupt sources in sequence. The highest priority is tested first.
- The particular service routine of the highest priority device is served.

- The disadvantage is that time required to poll them can exceed the time to serve them in large number of IO devices.  
Using Hardware:

- Hardware priority system function as an overall manager.
  - It accepts interrupt request and determine the priorities.
  - To speed up the operation each interrupting devices has its own interrupt vector.
  - No polling is required, all decision are established by hardware priority interrupt unit.
  - It can be established by serial or parallel connection of interrupt lines.

### **Direct Memory Access (DMA):**

In the Direct Memory Access (DMA) the interface transfer the data into and out of the memory unit through the memory bus. The transfer of data between a fast storage device such as magnetic disk and memory is often limited by the speed of the CPU. Removing the CPU from the path and letting the peripheral device manage the memory buses directly would improve the speed of transfer. This transfer technique is called Direct Memory Access (DMA).

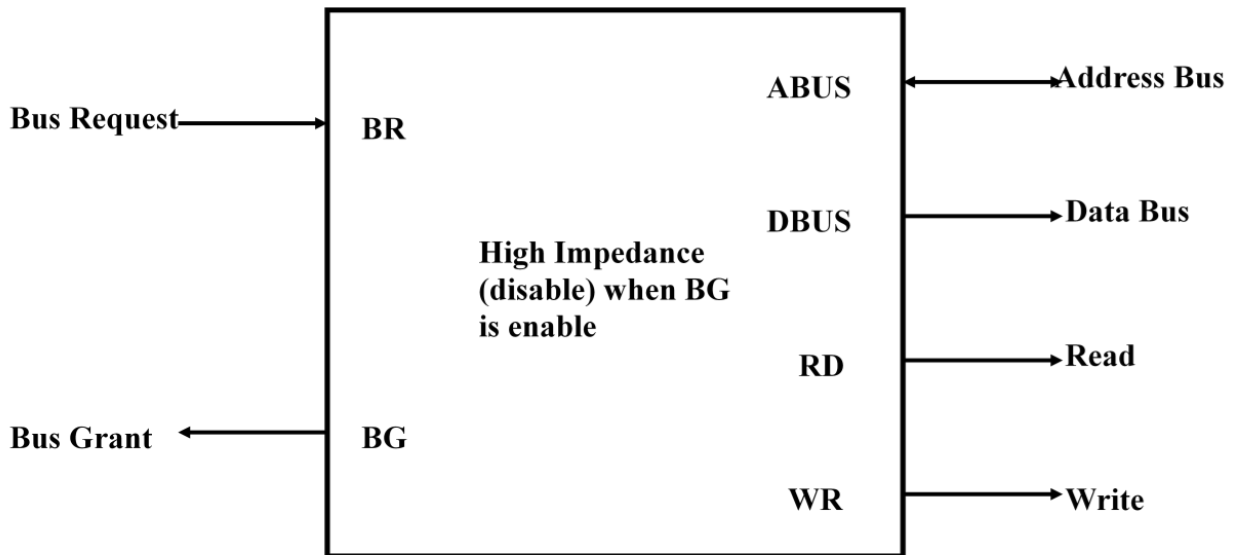
During the DMA transfer, the CPU is idle and has no control of the memory buses. A DMA Controller takes over the buses to manage the transfer directly between the I/O device and memory.

The CPU may be placed in an idle state in a variety of ways. One common method extensively used in microprocessor is to disable the buses through special control signals such as:

- Bus Request (BR)
- Bus Grant (BG)

These two control signals in the CPU that facilitates the DMA transfer. The Bus Request (BR) input is used by the DMA controller to request the CPU. When this input is active, the CPU terminates the execution of the current instruction and places the address bus, data bus

and read write lines into a high Impedance state. High Impedance state means that the output is disconnected.



#### CPU bus Signals for DMA Transfer

The CPU activates the Bus Grant (BG) output to inform the external DMA that the Bus Request (BR) can now take control of the buses to conduct memory transfer without processor.

When the DMA terminates the transfer, it disables the Bus Request (BR) line. The CPU disables the Bus Grant (BG), takes control of the buses and return to its normal operation.

The transfer can be made in several ways that are: i. DMA Burst

ii. Cycle Stealing

- . i) DMA Burst :- In DMA Burst transfer, a block sequence consisting of a number of memory words is transferred in continuous burst while the DMA controller is master of the memory buses.
- . ii) Cycle Stealing :- Cycle stealing allows the DMA controller to transfer one data word at a time, after which it must returns control of the buses to the CPU.

### DMA Controller:

The DMA controller needs the usual circuits of an interface to communicate with the CPU and I/O device. The DMA controller has three registers:

- i. Address Register
- ii. Word Count Register
- iii. Control Register

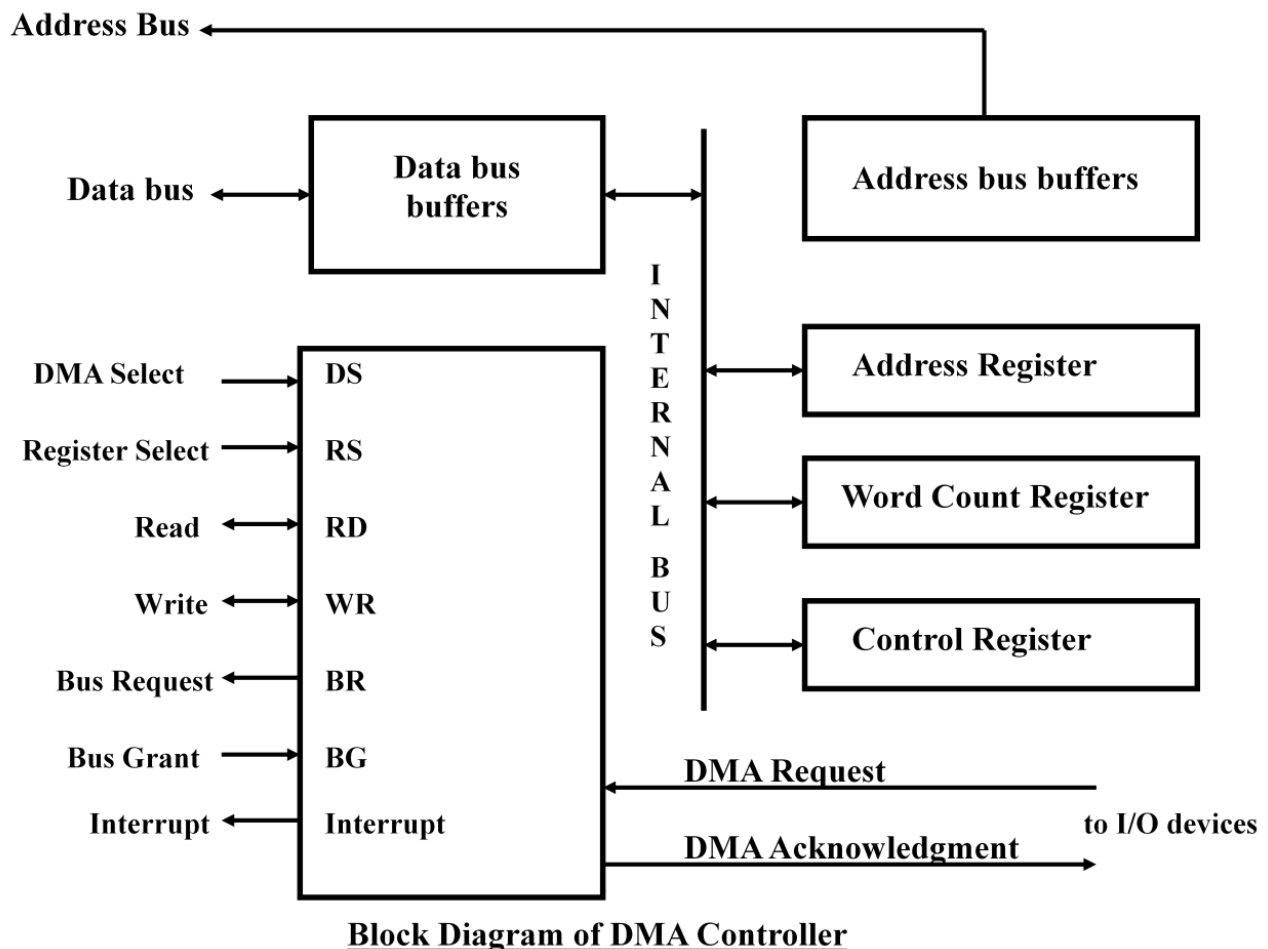
i. Address Register :- Address Register contains an address to specify the desired location in memory.

ii. Word Count Register :- WC holds the number of words to be transferred. The register is incre/decre by one after each word transfer and internally tested for zero.

i. Control Register :- Control Register specifies the mode of transfer

The unit communicates with the CPU via the data bus and control lines. The registers in the DMA are selected by the CPU through the address bus by enabling the DS (DMA select) and RS (Register select) inputs. The RD (read) and WR (write) inputs are bidirectional.

When the BG (Bus Grant) input is 0, the CPU can communicate with the DMA registers through the data bus to read from or write to the DMA registers. When BG =1, the DMA can communicate directly with the memory by specifying an address in the address bus and activating the RD or WR control.



### DMA Transfer:

The CPU communicates with the DMA through the address and data buses as with any interface unit. The DMA has its own address, which activates the DS and RS lines. The CPU initializes the DMA through the data bus. Once the DMA receives the start control command, it can transfer between the peripheral and the memory.

When  $BG = 0$  the RD and WR are input lines allowing the CPU to communicate with the internal DMA registers. When  $BG=1$ , the RD and WR are output lines from the DMA controller to the random access memory to specify the read or write operation of data.

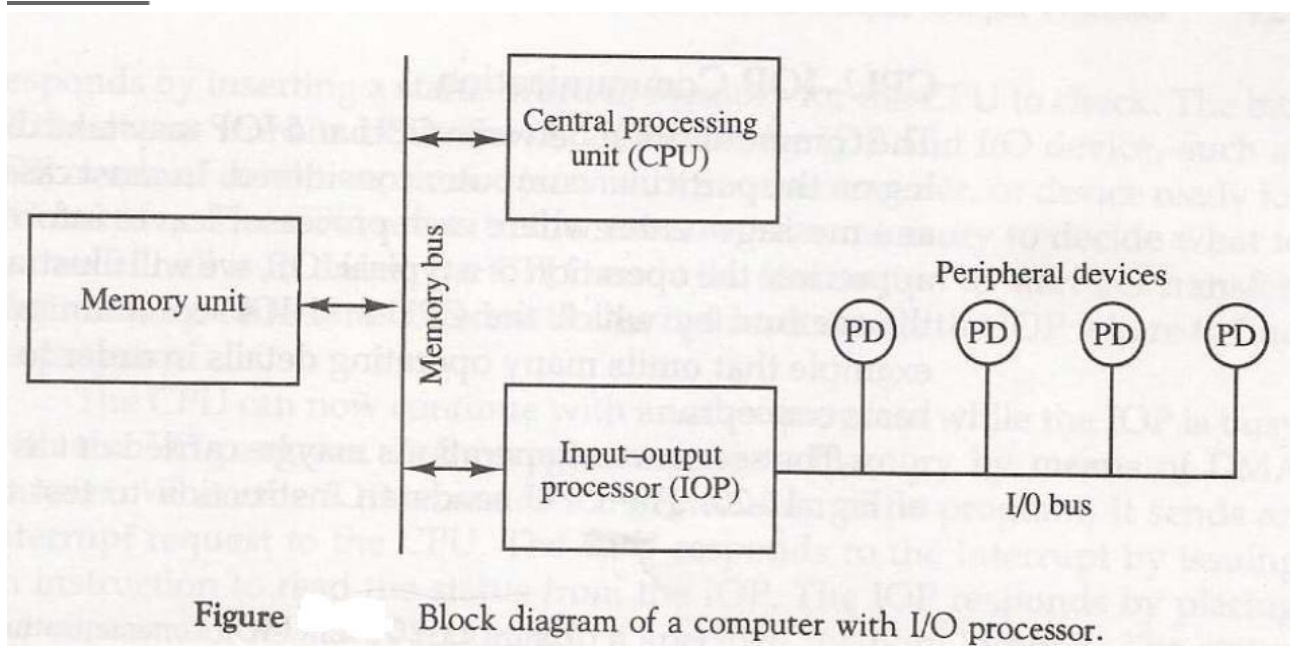
Summary :

- Interface is the point where a connection is made between two different parts of a system.
- The strobe control method of Asynchronous data transfer employs a single control line to time each transfer.

- The handshaking method solves the problem of strobe method by introducing a second control signal that provides a reply to the unit that initiates the transfer.
- Programmed I/O mode of data transfer the operations are the results in I/O instructions which is a part of computer program.
- In the Interrupt Initiated I/O method an interrupt facility an interrupt command is used to inform the device about the start and end of transfer.
- In the Direct Memory Access (DMA) the interface transfer the data into and out of the memory unit through the memory bus.

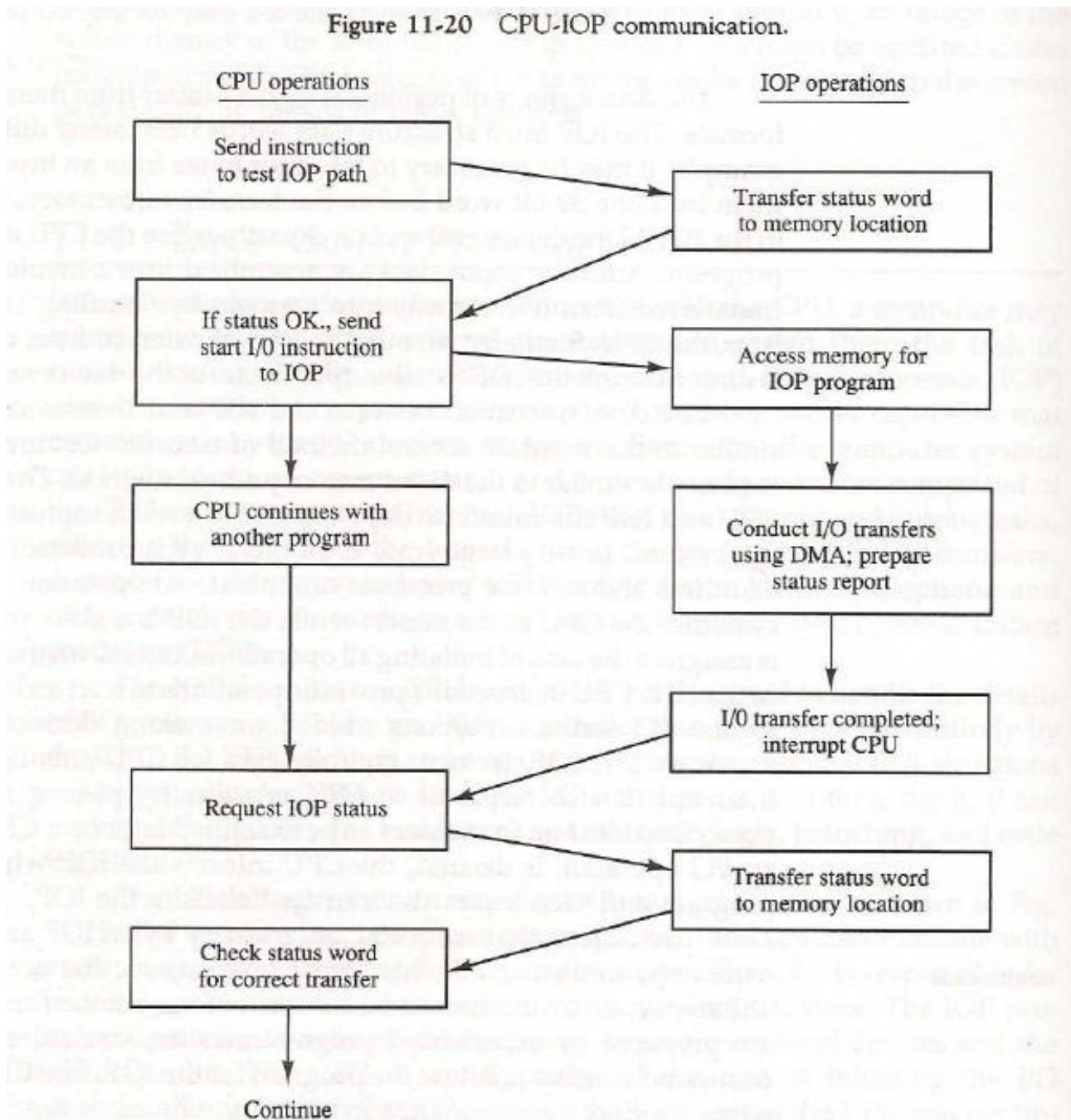
### Input-Output Processor:

- It is a processor with direct memory access capability that communicates with IO devices.
- IOP is similar to CPU except that it is designed to handle the details of IO operation.
- Unlike DMA which is initialized by CPU, IOP can fetch and execute its own instructions.
- IOP instruction are specially designed to handle IO operation.



- Memory occupies the central position and can communicate with each processor by DMA.
- CPU is responsible for processing data.
- IOP provides the path for transfer of data between various peripheral devices and memory.
- Data formats of peripherals differ from CPU and memory. IOP maintain such problems.
- Data are transfer from IOP to memory by stealing one memory cycle.
- Instructions that are read from memory by IOP are called commands to distinguish them from instructions that are read by the CPU.

Figure 11-20 CPU-IOP communication.



Instruction that are read from memory by an IOP

- » Distinguish from instructions that are read by the CPU
- » Commands are prepared by experienced programmers and are stored in memory
- » Command word = IOP program