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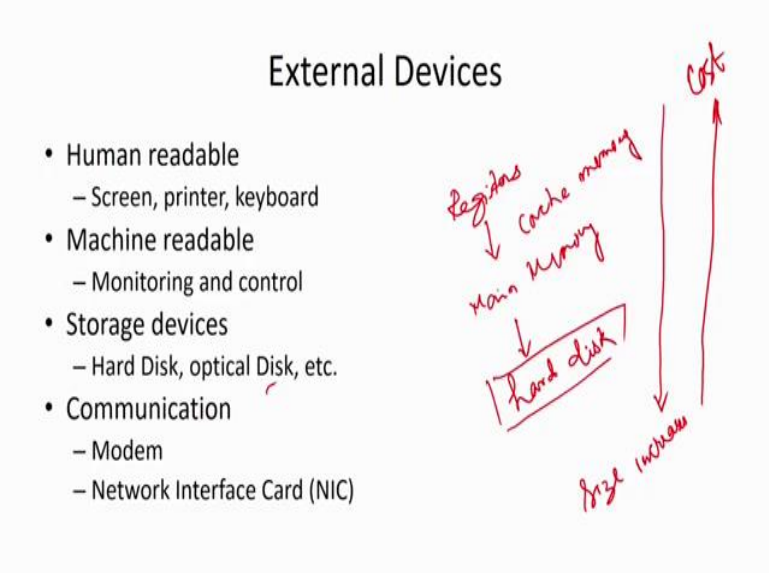

So, like that screen. If we are displaying something or say if you press some keys in the keyboard then that character will be displayed in the screen. Similarly printer, so if we are storing something in our hard disk. Now we can transfer it to the printer and we can print it. So, these are basically human readable devices; like screen, printer, keyboard and like that.

So, we are having some devices which are machine readable. So, this machine readable devices are basically used for monitoring and controlling purposes. So, in this particular case I can give a simple example. So, when we are using our computer at to switch on a machine or to work with a machine, sometimes we used to give password. So, when you enter a password then only you can enter into the machine and you can work with the machine.

Now, this is a password, it is a string of characters generally we use, but instead of that what we can do. We can use some devices also some other features also to unlock the computer like one simple example is your fingerprint. So that means, what will happen we can lock our machine with the help of fingerprint. Now when we are going to unlock it at least you have to give our fingerprint to it; that means, we have to connect a biometric devices to the computer. So, this is the fingerprint recognition.

So, this is something like your machine readable devices; like that we can uh, we can get many more examples of the machine readable devices the third category we are talking about the storage devices. So, most of you know that you are having hard disk and many a time you said that the capacity of your hard disk is maybe your 500GB or 1 terabyte.

So, what basically we are doing? We are storing our information in hard disks. So, when we are going to work with a computer, we bring the information from hard disk to the main memory and processor is going to take the information from main memory and it will be going to put into the registers that we have inside the processor.

So, in that particular case, so when we are talking about the storage or memory. So, now, you see that, we can have a hierarchy of the memory. So, first we can talk about the registers inside a processor. Then next level is your main memory, then next level is you can say hard disk ok. So, this is the memory hierarchy and I think now, after going through this particular course, when you have gone through this memory module, then I think you have encountered with one another kind of memory which is known as your cache memory.

So, in the hierarchy cache memory will come after the register. So, top level hierarchy is your registers then cache memory, main memory and hard disk. If you see these things then what will happen. If you go from this top to bottom then what will happen in that particular case, the size increases ok. Basically, so we are having a few limited number of registers, it may be 8, 16 or maybe 32, but when we are coming to the cache memory it is slightly bigger, so we can have that some Mbs of your cache memory.

Now, when we come to the main memory, you will find that in main memory you having 2 Gb or 4 Gb many memories nowadays, but when you come to the hard disk, you will find that you are having a abundant capacity, maybe around 300 Gb, 500 Gb even terabyte also. So, size increases when you go from this particular register to the external devices like hard disk. So, these are the things. Now in the second issue is when you go in this direction then cost increases. So, cost per unit memory is increases.

So, that is why we cannot keep everything in main memory or we cannot keep met with more register. If you are going to give more register then cost will increase. So, this is the way we can just look for the hierarchy. So, these are external devices where we can store our information. So, like that we are having optical disks also, many a times you know about the CD compact disk ok. So, you can store, say one complete movie you can store in your CD.

Now when we are going to play the movie then what will happen? We are bringing the information from CD to the main memory and processor is going to take the information from main memory and accordingly it is going to display also. So, similarly we are having some

devices for communication purpose also. So, one is your modem and another one is your network interface card. So, these are communication devices.

So, we are having a varieties of external devices, their purposes are different, the transfer rate is different, the format of data that we have storing information is different. So, to handle all those issues we are having this particular I/O module. Now we are going to see what basically we are having.

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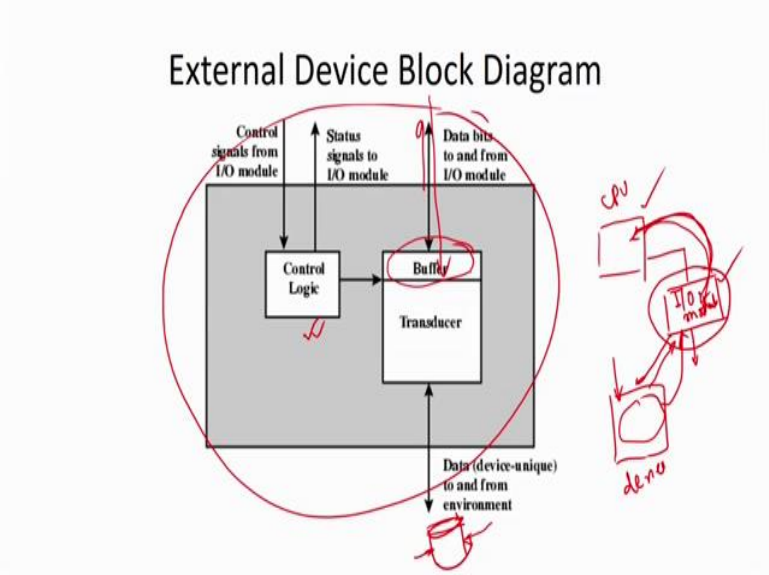

So, now, we said that this is I am having the processor CPU. So, this is connected to the I/O module and different devices are connected to this particular testing. So, this is a device. So, what basically we should have in the device. So, we should have a controller who control that particular device. So, this is the external device block diagram or that controlling of the particular device.

So, what basically we are having. We are having a control logic over here. This control logic is going to receive the control signals from I/O module. So, this is connected to these things, it is going to receive some control signal from the I/O module depending on those particular control signals, this control logic is going to control the devices.

Now one example may be like that control, that I/O module is giving a control signal like that it wants to read some information from this device, maybe you just think that this is a hard disk and we are going to read something from the hard disk. So, I/O module is giving a signal control

signal to it, now control logic is going to perform the appropriate operation and it will give some signal to the I/O module. Maybe one of their control signal may be the status of this particular device, whether device is ready or not like that.

So, some status information will be given to the I/O module. Once I/O module will receive the status information and what will happen now it knows that, now it can transfer the information. So, in that particular case now this is the device that you are connecting to this particular controller. So, it maybe the hard disks that we are connecting to it. So, we are storing the information in this particular hard disk.

Now device controller is going to read the information and we are having a transducer over here, what transducer does basically if. Basically if you look the basic definition or the generic definition of transducer, basically it says that it can transfer the energy from one form to another form. So, here also you can say that it is transferring the information from one form to the other form. So, when we are talking about the hard disk the, what is the basic principle, this is magnetic in nature.

When we you are using an CD then what is the nature, this is the optical in answer; that means, you are storing information with the help of magnetic property or we are storing information by using the principle of light. So, now, when we are going to get information then this transducer is going to convert it from that magnetic information, magnetic information to the electronic information or electrical signals.

Similarly that light in principle of light will be converted the electrical signals. So, this transducer is going to convert information from one form to the other form and finally, it will be buffered over here and it will be stored in this particular device driver itself. So, you are having a very limited space over here. Like that when you press a key in the keyboard, so it is a mechanical device, so you are pressing it.

So, what, when you press the keyboard with respect to that particular key, some information will be stored into the one buffer or one register in that particular keyboard itself and after that that will be transferred to the processor through I/O module. So, we are taking the information through transducer you are converting into the appropriate format; that means, you are converting or sending it to the electrical signals then we are storing into the buffer and once we are getting it then we have going to give it to the I/O module.

So, that data is transferred to the I/O module. And once data is available in the I/O module, then I/O module is going to transfer this information to the processor. So, this is the way we can look into; that means, you just see that, in the hierarchy now we are having three component; one is your processor, I/O module is connected to the processor and the devices are connected to the I/O module and for every device we are having a device driver ok, or you can say that this is the control for that particular device.

So, this will device, what is that device we are having or what is the electronic circuit or what is that driver that we are having that is specific to a particular device, so this is specific to this particular device. So, whatever their external device block diagram you are writing over here that will be specific to a particular device, but this I/O module is generic one, we can connect any type of I/O devices to the I/O module and that I/O module will be connected the processor.

So, these are the steps that we are going to have when we are going to transfer information from say input devices to the processor and similarly when we are going to transfer information from processor to the output devices it will follow the same thing. So, basically, now if the way I am saying that I am going to read something some information from this hard disk. Now similarly we may want to store some information to this particular hard disk, then what we are going to do.

From processor it will give to the I/O module, through I/O module it is going to coordinate with this particular control signals, after that from I/O module it will be transfer to the device driver, it will come to the buffer then from buffer through transducer, it is going to convert it to the appropriate signal. So, if there is a hard disk then from electrical signal it will convert to the magnetic signals or if you are using a CD compact device then what will happen, that electrical signal will be converted to the light signal ok. This is the way we are going to transfer information.

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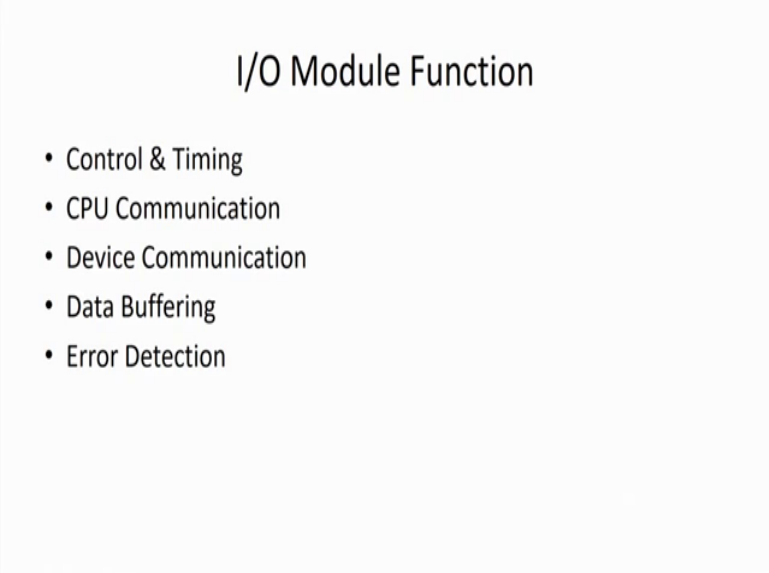

Now, what are the I/O module functions, already I have explained many more things. So, this is in nutshell you can say that. First one is your control and timing. So, this is the control circuit, control logic circuit that we are having. So, you have to synchronize the time, because the speed of this particular device is much slower than a processor. So, that's why we are having this particular buffering, first we buffer it, then we will transfer to the I/O module from I/O module to this thing.

So, we have to synchronize the whole operation, so that it works in a coherent manner. So, for that we need many more control signal and timing signal. So, this is basically, it generates the timing signal and it generates the appropriate control signal to control the devices. So, in this particular module we are going to see what are the different kind of control that we may have for devices.

It is difficult to discuss for all the devices, at least we will discuss one devices to see what are the control signals that we have for the particular devices. Second one is your CPU communication. Already I said that that I/O module is connected to the processor through this particular system bus. So, communication to the CPU will be done through this particular I/O modules on there. Then device communication, just see the previous slide, I am saying that through the I/O modules we are connecting the device. So, there is a communication between devices devices also.

So, this is your device communication and this is your CPU communication. So, I/O module is responsible for control and timing, CPU communication, device communication, another one is data buffering. Already I have mentioned that devices are working in different speed ok and different format also. So, to transfer information from device to I/O module will take more time, because devices are basically slower than the processor.

So, that is why I/O module is going to buffer the information, first it will collect the information from input devices, it will buffer over here. When that I/O module is collecting sufficient information then it is going to transfer the information from I/O modules buffers to the processor, because both are electronics component, relatively they are having the same speed, but my devices are not properly electronics component they are having mechanical movement also, so they are slower. So, this is the buffering.

Secondly, say if you want to print some files generally many a times you know, you write a letter then you send it to the printer, you are going to get a printed copy of that particular letter. So, basically what it does, printer is a slower device. So, if processor is going to directly interact with the printing or printer then what will happen? Many a time processor needs to wait. So, for that particular case what will happen?

First, processor will transfer information to the I/O device, I/O module. So, I/O module is going to buffer it and after transferring a sufficient amount of information, then I/O module will transfer that information to the printer and printer is going to carry out the printing job. So, this is the data buffering; that is going to be carried out by I/O module. So, this is a function of the I/O module and another one is also error detection. So, sometimes it is a transfer of information, it is in bit transfer only, we are transferring 0s and 1s. So, if some 0s are converted to 1 during transfer then what will happen? We are going to get an error. So, we are getting an erroneous information.

So, in some of the cases in I/O modules can detect some of the errors also and it will notify the processor that whatever information it is getting is having some errors. So, that error detection is also a part of this particular I/O module. So, it is another functionalities of the I/O module. So, what are the I/O steps?

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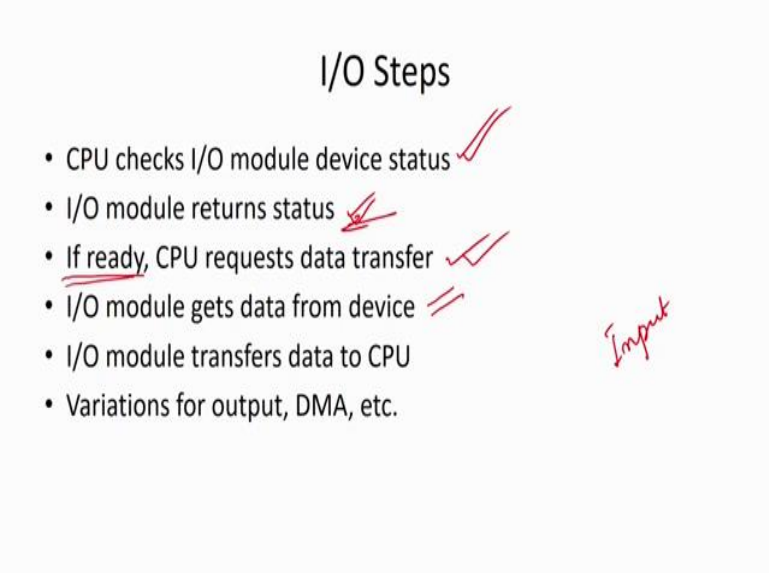

Now you just see that when I am explaining it, it is coming in a flow now. I think most of the things already I have mentioned when I discussed about this particular external device block diagram. So, now, what after all looking, having knowing the functions of the I/O module, now we are going to say what are the I/O steps. So, now, you just see it is very clear now CPU checks I/O modules device status.

So, basically first CPU checks what is the device status. Now I/O module returns the status. So, processor is going to, say just think that particular example that we want to print a file. Now we are giving a print command, now processor is going to carry out this particular job then what will happen. Now processor checks the status for I/O modules. So, it is going to give a signals and it will say that we want to use the printer then what will happen.

Now I/O module is going to check the status of the exit device, whether printer is ready or not, whether printer is switched on or not. If everything is ready I/O modules returns the status. So, when processor get the status, yes it is ready then what will happen. We can carry out the output operation, it going to send the information to the printer.

So, if it is ready. So, once that I/O module is returning the status, now processor is going to check, whether it is ready or not. If it is ready then CPU requests data transfer. So, it may be an input transfer or output transfer. For printer it maybe an input operation a, sorry for printer it may be an output operation, but if you are reading a file then it may be an input operation. So, if ready CPU requests the data transfer. Now I/O modules get the data from the device.

So, here in this particular step, if you are going to look into it, basically we are going to talk about the input operation. If we are going to look for the output operation then this step would have been slightly different, it will say that I/O module would get the data from the processor. So, basically from here we are going to look for it. So, I/O module get data from the device. So, since device is ready, now, I/O module is going to get the information from device. So, basically if you say that I am going to read a file from a hard disk.

So, now, I/O module is going to collect the information from data, because it is having a buffer, so it is going to at least collect the information that may be accommodated in the buffer space, then I/O modules transfer the data to the processor ok. Now once it is collects the information is storing it in the buffer then I/O module will transfer it to the processor. Then this is the way that we are going to complete it.

Now here we having variation of outputs and for that we are going to discuss what are the differences we can do it. So, that is we are saying that there are the variations for output and variations for input also, where DMA will come in to picture, so we will discuss that thing also. Now we have seen the devices there and for that we are having a device controller we have seen these things.

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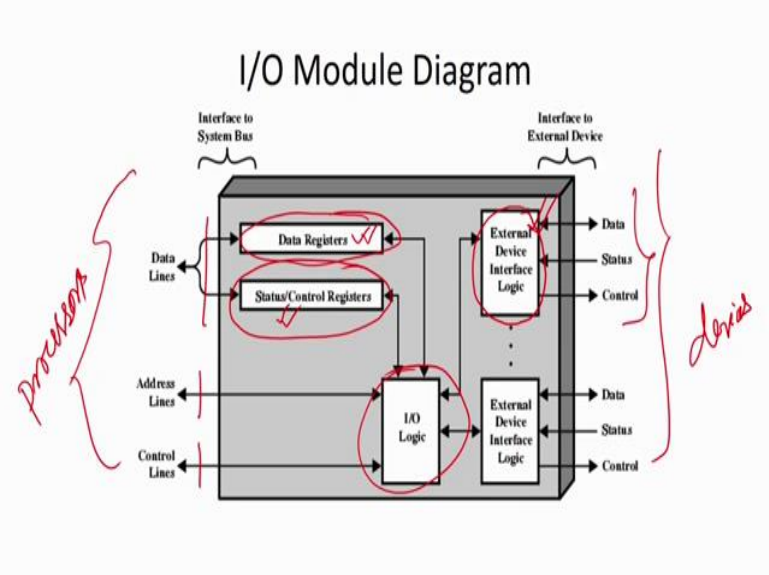

Now, these devices will be connected to the I/O module now just see that top level block diagram of the I/O module. So, these are the things that we are going to connect to the processor, this side we are having the processor and these are we are having the devices. So,

this is connected through our system bus. So, we are having this particular data bus, we are having that address bus and we have this control lines ok. So, this is the system bus and we are connecting it to the processor.

Now here we are having two basic register; one is known as your data registers and second one known is your status or control registers. So, now; So, when processor request for a device, then this I/O module is going to check for the status of this particular device and accordingly status of device it will set this particular status bit over here and this particular status bit will be monitored by the processor and depending on the status bit it is going to transfer the information and that transferred information will be go through this particular registers, which is a data register.

So, similarly here we are having that address lines we are giving the addresses and we are giving some controls like that, it is an input operation or whether it is an output operation all those things will come and after reaching this particular information that here we are having an logic circuitry I/O logic circuitry and this logic circuitry is going to identify which device basically we are going to use, it depends on the contents of the address line.

So, we can connect different devices. So, it is going to identify one of the devices depending on the address, depending on the controllers it will going to say what is the operations that we are going to perform, whether it is read or write. So, here we are having an external device interface. So, maybe here, we may have a space for buffer also. So, we are going to collect that information to the buffer and from that buffer through this data register we are going to transfer it to the processor.

So, this is again another interface logic circuit that we are having to handle this particular I/O devices. So, one simple control signal I can think about, I can just mention here like that. So, when we are going to print a file then what will happen? We have to place the printer head at the proper position, maybe start of the line.

So, this control signal, it will send a control signal like that this particular interface logics to initiate the printing of to set the printer properly; that means, bringing the printer head to the proper position. So, these are the control signal that we have to see. So, this is the way that we are going to connect. So, this is the generic view of I/O modules. So, according to our requirement we have to design these things. So, these are the basic components you should

have one is data register, one is status or control register, one control logic circuitry and device interface logic circuit for different devices.

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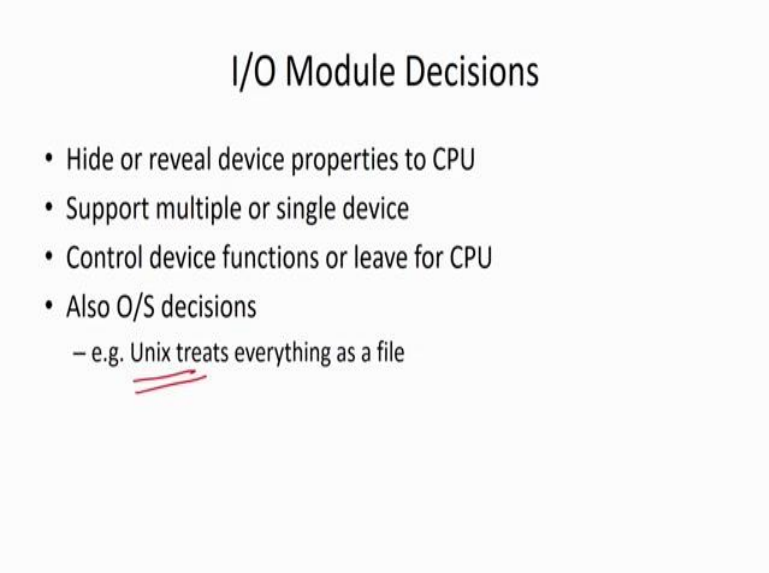

So, what are the I/O modules decisions? Already we have seen the functionalities, so basically what is this, it is hide or reveal device properties to the CPU, because. So, processor is going to work with the electronic signal, it will basically going to work with your bit stream of 0s and 1s.

So, in what format we are storing in the device, in what way we are organizing the all information, this may not be relevant for the processor. So, we can hide those information and you can shift everything to the I/O module and I/O module is going to take care of everything. So, it may hide or in some cases it may reveal the device properties to the processor also. Support multiple or single devices. So, already here I have said that we are having a provision to support multiple devices. Generally we are having I/O modules to support multiple devices, control device function or leaves for processor. In most of our cases it is going to control the device function also, basically like that one example I can say that while going to print it, I have to place the printer head in a proper position. So, that will be done by my I/O module. So, this is some controlling of the devices also, some I/O decisions. So, depending on the instruction that we have in the instruction set of the processor, we can write the appropriate routine for my operating system.

So, some of OS decisions will also be taken care by I/O module, so you have to send something to the I/O module also. So, these are set one for example, it says that if we have that Unix operating system, say you know that we are having several operating system 1 is Unix, maybe windows, most of you are accustomed to the windows. So, in case of UNIX operating system it has defined like that everything will be treated as a file. So, if we are connecting an I/O devices that I/O devices will be a treated as a file; that means, it will say that simply say that, it is having a file id and with the help of that file id we are going to control that particular devices.

So, some ways decision will also be transferred to the I/O modules all right. Now what are the different techniques that we have in your input output, how we are going to do it.

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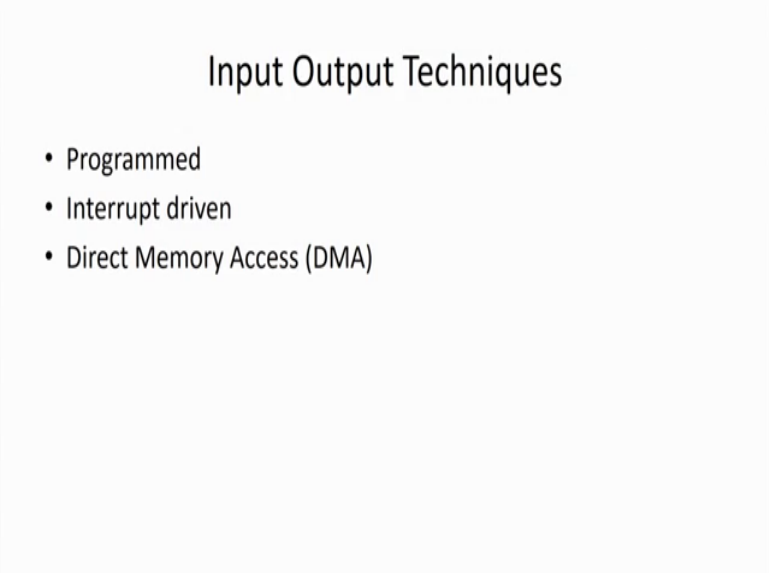

So, if you are look into that way of transferring information. Basically we are going to get three different way of transfer our information; one is your programmed I/O, second one is your interrupt driven and third one is your direct memory access or DMA. So, here we are going to discuss about those three different techniques the way we are going to transfer our information. So, in this particular case in a nutshell I am going to just give you the brief idea, what are the differences between these three methods.

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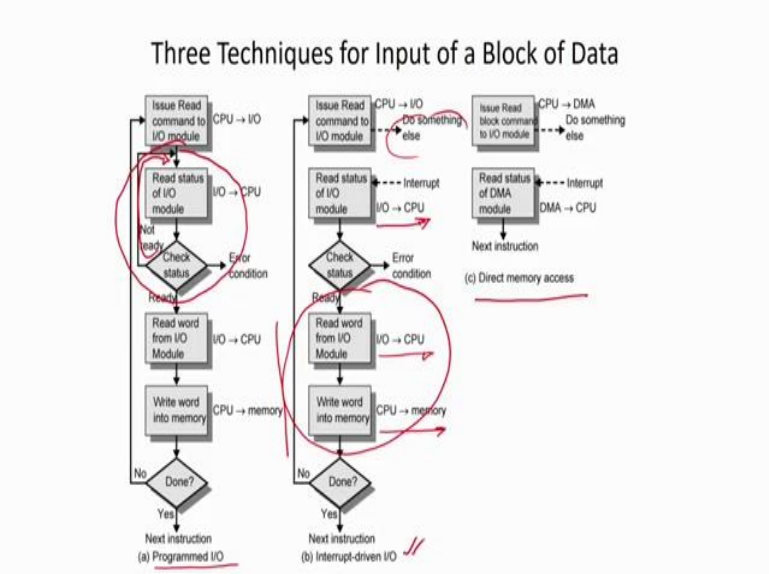

So, this diagram it says that, we are going to perform some I/O operations, so CPU initiates the I/O devices. Then reach status of the I/O modules. So, processor is going to read the status whether device is ready or not. So, in that particular case if device is not ready, it will check whether or not device is ready, if it is not ready then it will remain over here. So, it will keep on waiting in that particular loop.

So, basically we say this is the busy waiting and during that time processor is not doing any work ok, processor is idle just, it is busy of checking this particular status. Once the device is ready going to perform the other operation, maybe take the information from the input devices, put it into the memory again after completion of the job again go to this.

Now, you just see this is the point where we have to look into. Processor want to work with an input output devices and it is going to check the status, if it is not ready then it will be in this particular loop and we say this is that busy waiting and in that particular time processor is not doing any useful work. So, this is the wastage of our processor time. So, this is called programmed I/O, we are going to control the devices with the help of one program and through the program we are going to check it.

Here main drawback is your wastage of processor time. So, that's why we are thinking how that wastage of time can be minimized or can be removed. So, for that that second one is coming which is your interrupt driven io. So, this portion is same. Now what will happen? Now processor is going to give a signal or give intimate to the I/O module that processor want to do

some I/O operation, may be taking something from the input devices or going to put something in the output devices. After giving this information to the I/O module now, processor is going to carry out its own work. It is not going to wait for the status, it is not going to check the status of the device, it is just simply give the information to the modules and after that processor is going to carry out its own work, because if we are executing a program, processor is going to execute that program from that particular point. When one I/O module is getting this particular information now that processor want to interact with some input output devices, then I/O module is going to look for the status of this particular input devices or maybe output devices, when device is ready and everything is there, just to start of the transfer operation at that particular time that I/O devices is going to give the information to the processor, this is reset, this is now input output module is going to interrupt the processor, now interrupt is doing some job. Now I/O module is going to interrupt it.

So, at the particular point now processor will be knowing that now that device is ready or data is ready, now processor can work with this particular input output device. So, after it checks status and carry out these particular transfer of information after completion of the transferring of information again we go to this point. So, here in this particular case you just see what we have done.

We are eliminating that particular busy waiting or wastage of time, but now come to this particular point, what we are doing, when you are going to have the read then from I/O devices we are going to transfer to the processor and processor we are going to put it to the memory is that input operations or. Say, that from we want to take some information from hard disk and then to put in to the memory.

So, first we are bringing in to the processor, we are bringing in to the processor means, we are putting into some register of the processor and from that processor register we are putting in to the memory. Similarly if I want to write some things or save some file to the hard disk then what will happen? First we are going to take it from the memory to the some register of processor and from the processor register we are going to transfer it to the I/O module and from I/O module it will go to the output device may be hard disk.

So, you just during this transfer, the processor is involved, processor cannot do any other work, it is simply transferring the information from maybe hard disk to the memory or maybe from memory to the hard disk. So, again we are thinking now how to eliminate this particular

involvement of processor. So, that direct, we can some other way you can simply transfer our information from hard disks to the memory directly without the intervention or without taking help of the processor, so that I need not to go through the processor.

So, for that the third process is coming which is known as your DMA direct memory access. So, in that particular case what will happen? Now say when we want to read a file from the hard disk to the processor memory then what will happen? Instead of sending through my processor registers straightaway we can bring it from hard disk to the memory. So, this is direct memory access. So, initially that processor involvement is there; like that to initiate the input output operation.

But at later point of time this processor involvement is may not be required, directly you can transfer from hard disk to the memory or from memory to the hard disk. So, this is basically talk about the bulk data transfer. So, if I want to transfer a file size of say 1 Mb. So, I have to transfer a whole file. So, without taking the intervention of the processor.

Processor will be initiate the transfer after that straightaway we are going to transfer it from memory to the, sorry hard disk to the memory or maybe in case of writing from memory to the hard disk. So, this is we are accessing directly. So, we say this method is your DMA; direct memory access. So, now, in this particular module now, we are going to see the design issues and the walking issues or what are the implications that we have for these three kind of transfer. Now for that first one we are going to see about the programmed I/O. It is already I have mentioned that what basically you used to do we have to check the status, continuously once it is ready we have to do it.