VLSI Physical Design
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Lecture - 10
Pin Assignment

So, Pin Assignment - that is what we want to talk about in this lecture. Let us try to understand what this problem really means. See here we are trying to define the signal that each pin will receive what does this means. Let us take an example to illustrate.

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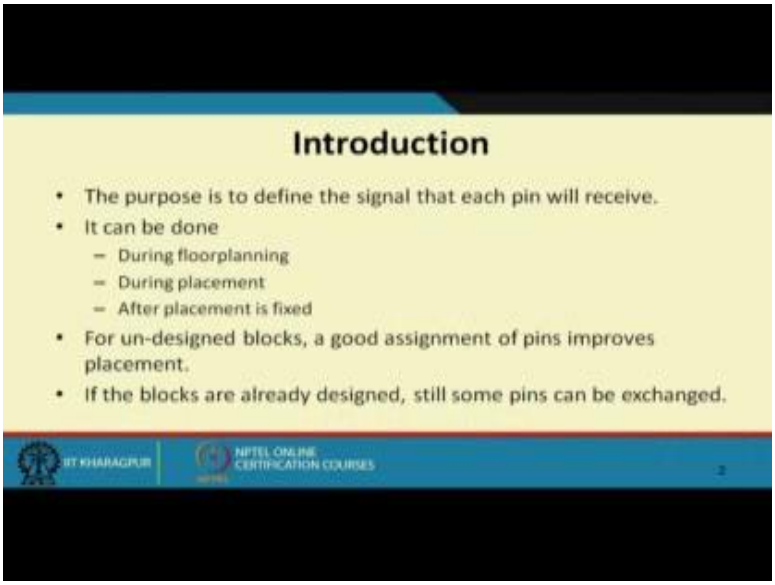

Let us say I have a block. This block consists of some kind of a gate level netlist; it is can be a anything. So, the exact circuit is not important.

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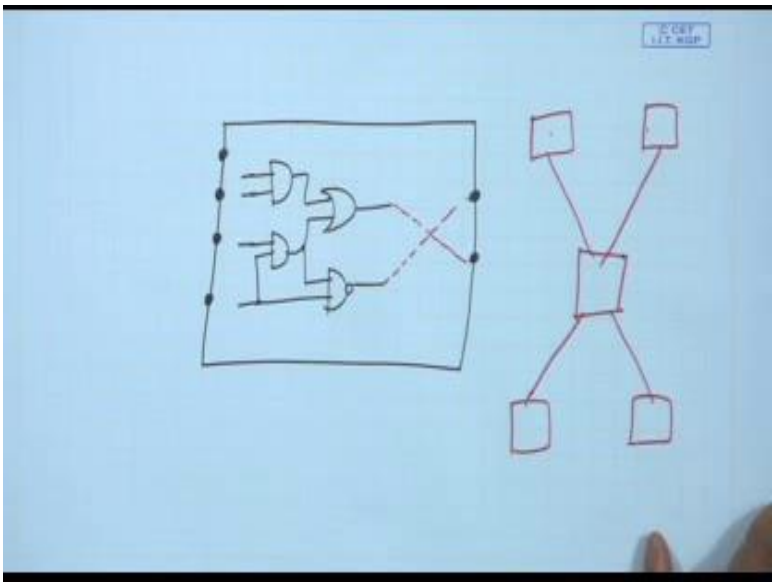

Let us say I have one output here. There can be another output coming like this. This is a circuit. So as you can see let say these 2 are also combined. So there are 4 inputs and 2 outputs. So externally there will be a total of 6 pins. 2, 2 input pins and 4 inputs pins and 2 outputs pins. Now this inputs and outputs pins are not necessarily true, that the input pins have to be placed on the left edge and output pin on the right edge. Input pins some of them can be placed on the top, bottom or it may be possible that it may be good if I connect this one to this, and this one to this, cross kind of a thing.

There are lot of issues. These issues will depend on not only this block which we are considering, but also to the other blocks, that are in neighbourhood and from there the connections are coming. So depending on the location of the other blocks you will have to judiciously the select where you have to put the pins. Now this decision we have to take for the so called flexible blocks. Flexible blocks will recall at the blocks which are not yet been designed their exact shapes and sizes are not fix, and also the exact location of the pins are not fixed. For those blocks we have to take this decision.

Now, this pin assignment can be done during various stages, during floorplanning. During placement I shall talk about this is a little later, during placement also this problem can come up. Not only that even after placement sometimes you may have to play around a little bit. This also I will discuss. This is something we which we just now said for blocks which are not yet designed, a good assignment of pins can improve not

only the placement, but also the interconnection routing, but also for the blocks which are already designed, there is also some scope for pin assignment, like let us take another example. Suppose I have a block like this, and I have another block like this.

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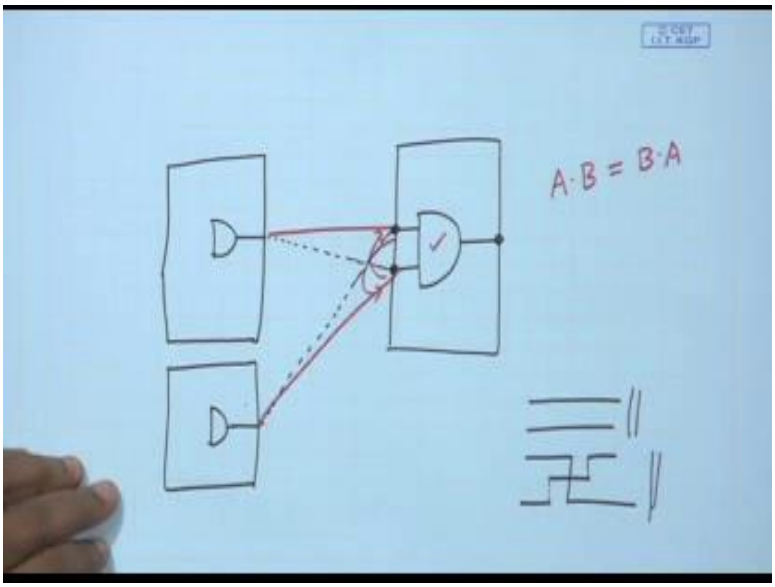

Let us say this block is just a 2 input gate. There are 2 inputs and one output this is a fixed gate and suppose there are 2 other blocks which are also fixed in there, they are already placed. So some circuit is generating this signal some other circuit is generating this signal. Now I have to connect this signal to this, and I have to connect this signal to this. Now you see here there is a cross in the interconnections. So wherever there is a cross in the interconnections laying out of this net will be little more difficult. It will take a little more space. This you can immediately see because if 2 connections have to made in parallel it is easy, but if it is zigzag then means one of them you can connect, but the other one there is a problem you may have to go to another layer then again connect like this, then like this so you have to move to another layer make a connection and then you have to make the connection. It will take 3 tracks instead of 2 tracks here. It will also take more space.

But what I mean to say is that, suppose this is and gate let us say, now since we know that the and function is commutative A and B, and B and A are the same. So it really does not harm if we swap or in exchange this pins bring this here, and bring this here.

That will make the connection straight. The functionality does not change; the output does not change. It is simple the end of these 2 functions right.

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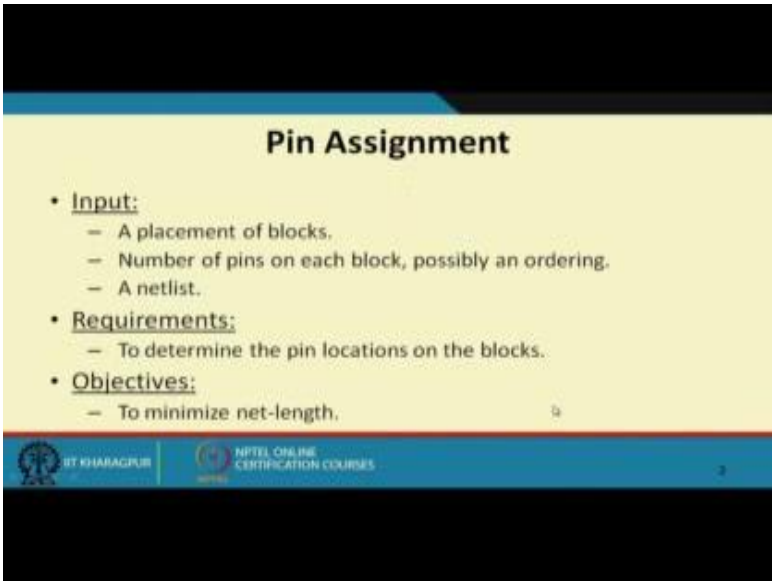

So, this is actually what I mean to say in this last point. So in this a pin assignment, the input is a placement of blocks, number of pins on each block. Possibly in ordering this ordering may or may not there. This ordering means well you know that there are 3 inputs and 2 outputs.

But you know that their order will be fixed. First input 1 input 2 input 3. Then output 1 output 2, but the exact relative locations you can move them around, but their ordering has to be maintained. This may or may not be there as a constraint.

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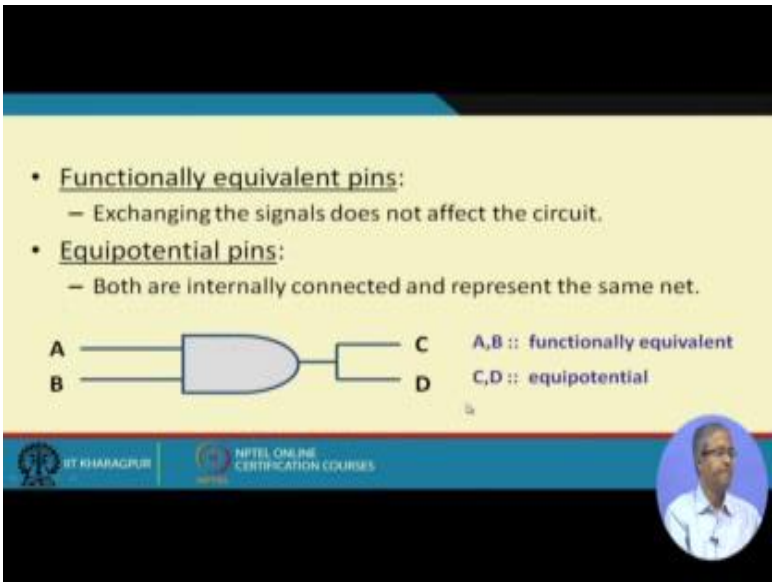

Objective obviously, would be to minimize the net length and also to see that minimum number of crossings are there. Functionally equivalent pins 2 pins, which carry the same signal it does not matter if I exchange them. This equipotential pins both are internally connected C and D. So you see C, D are equipotential. A B are functional equivalent, so the example I just now gave little earlier that is a example of a functional equivalent set of pins. So I can exchange A and B if required, without changing the functionality. Similarly, C and D are electrically connected I can also exchange C and D, without any problem.

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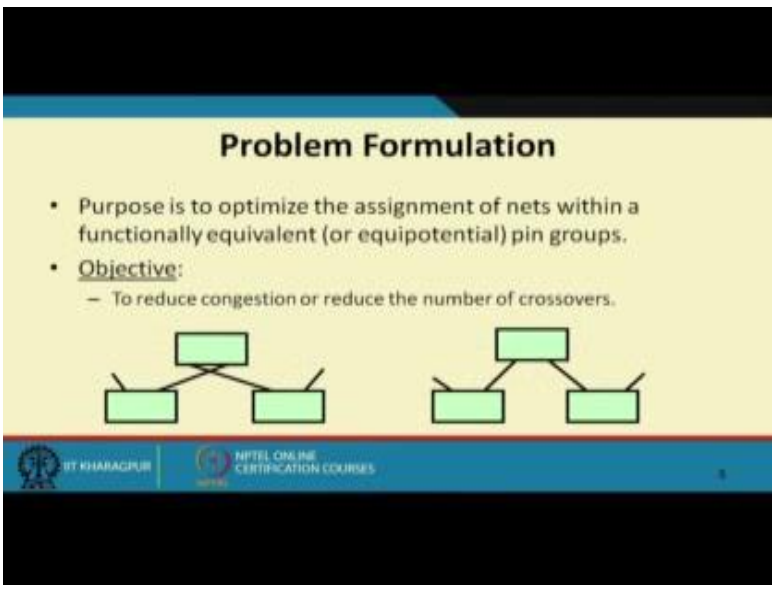

So, if there is a scenario like this, where C is connected somewhere D is connected somewhere. If required I can exchange them; if that means that my routing can be improved my placement and my words can be laid out in easier way I can do that all, right. So the purpose is to optimize the assignment of nets within functionally equivalent or equipotential pin groups. Objective as I have said to reduce congestion or reduce the number of cross overs. So the example that I just now took suppose this was such a case where these 2 pins, where you can see there is a cross in the inter connection they represent functionally equivalent or equipotential pins.

If such a cross is happening, you exchange them and make the connection like this. This looks much neater, much easier to inter connect. So the blocks can also be brought closer together here less area.

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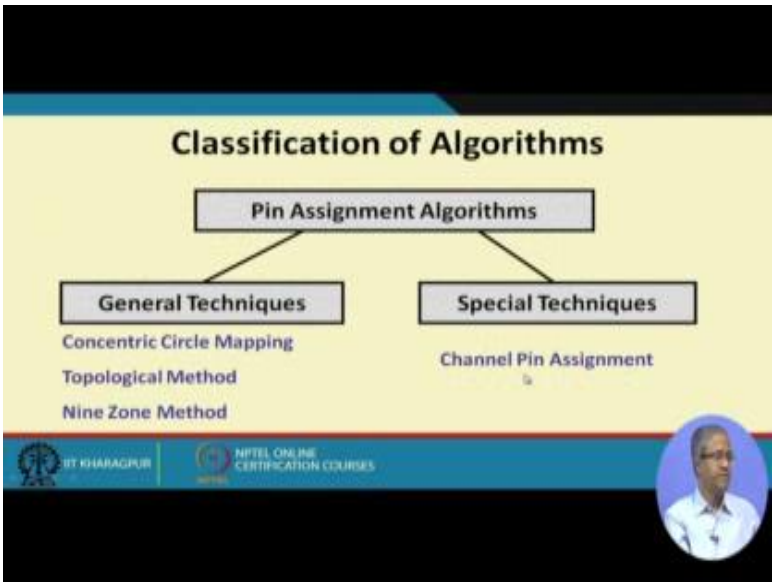

So here I shall not be going in to the very details of the algorithm. I shall briefly give you the basic idea regarding the possible approaches that people use for the pin assignment problem. So there are some general techniques which can be used for any general pin assignment instance, but some special techniques which can be used only for standard cell kind of design style, where you have the channels these standard cell rows and so on.

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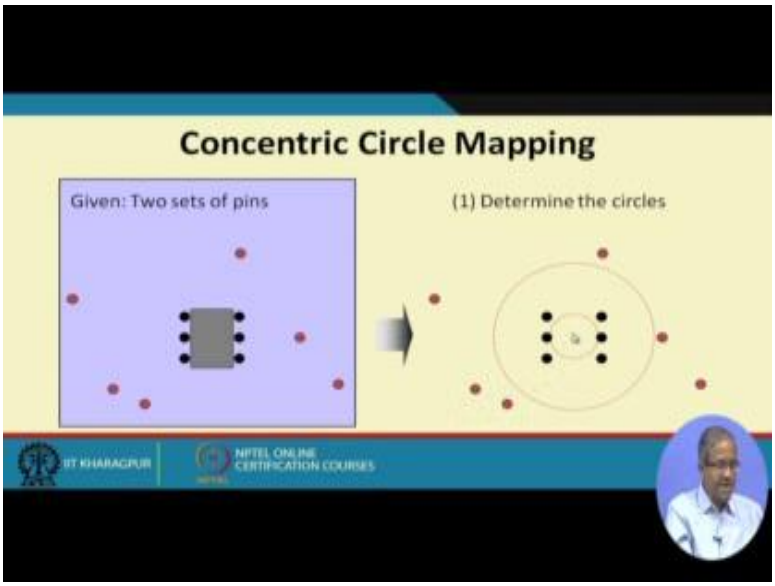

Let us see, the concentric circle mapping, this I shall be illustrating with the help of an example. So here let me tell you here the problem is that I have a block. This is the problem of one particular block, whose pins are flexible, but their ordering I am assuming is fixed you cannot change the ordering, but you can rotate them if you want. There is this block, which whose pins have to be connected to some external points. Some external other blocks which have already been placed and I am assuming their pin locations have already been fixed. So it is only the pin position of this current block that you are trying to adjust at this place. This is my problem which I am trying to illustrate. So you see this is my block whose 6 pins as you can see whose ordering I can change. I can rotate their (Refer Time: 10:15), this been I can bring here, this I can bring here, this I can bring here and so on.

But this external this points, which I shown as red they have to be connected to these pins. They are already fixed I cannot change this 6 right. So let us see what this concentric circle mapping talks about. First step, it draws 2 imaginary circuits one inside this group of 6 pins and the other outside this group of 6 pins, but inside the external pins. So you can see these 2 circles concentric circles right. These are imaginary we are drawing. Then from this centre of this circle we draw lines. From centre of this circle we draw lines to the 6 pins.

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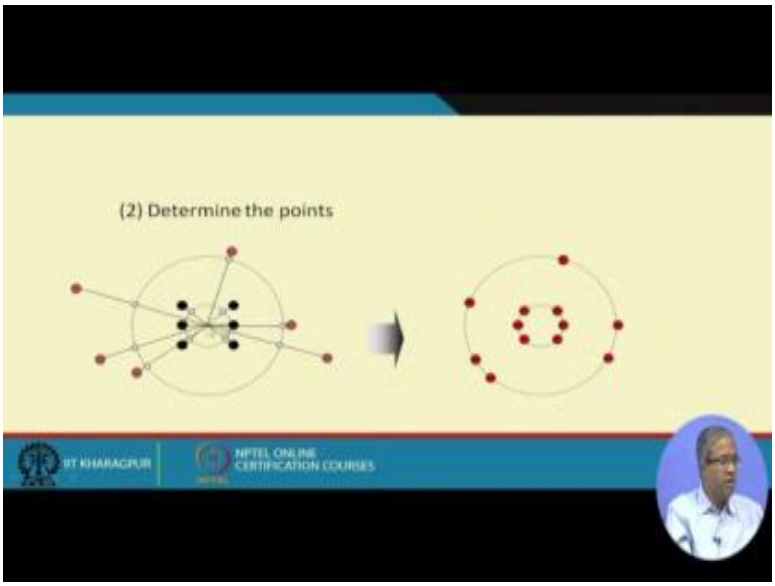

Let me go back once, say from the centre I draw line to these 6 pins. This lines will be intersecting the inner circles at some points, similarly I draw a lines to the external pins.

They will be intersecting the outer circles at some points. So that is shown in this diagram. The inner circle will be cut at these points which are shown, and the outer circle will be cut direct at these points that I show right. Now we forget the original pin locations we only consider this projection on this circles. These 6 points so the inner circle and the 6 points on the outer circle, just we temporarily forget the actual pins. So we take this, then we do some kind of a rotation of this circle.

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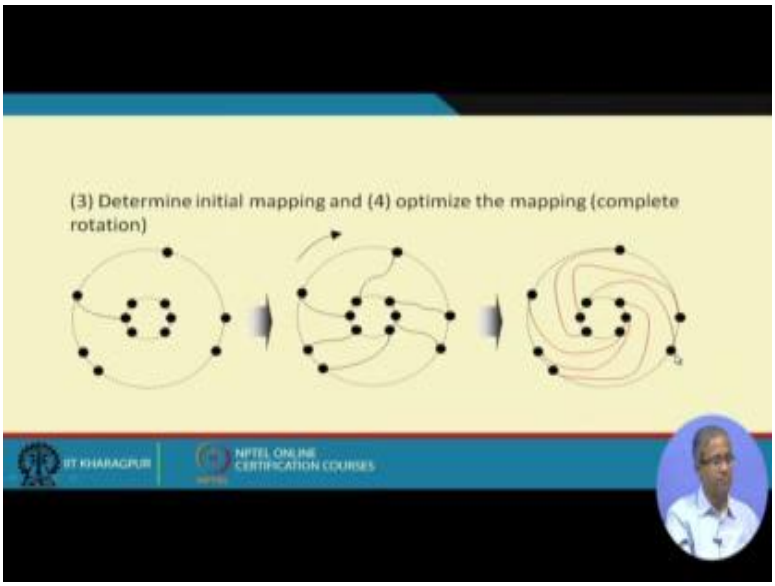

How? Then we try to find out initial mapping. First let us say initial mapping says, this pin is connected to this pin, this pin must be connected to this pin, this is connected to this pin. So the ordering is there. So now, you try to rotate them in some way. You see this is a bad rotation, if you rotate this pin to here then I have to connecting using long wires. So you try to rotate the pins in a way rotating in a way, such that the interconnections become simpler.

If you rotate in the wrong direction, then the wires will become very long. So you find out the optimum angle of rotation for which your interconnection lengths the total of them is minimized. So this can give you a good solution may be you rotating in in the right a little bit it will be even better, but this is a bad rotation. So once you get the good rotation this is the best rotation. So you connect them in straight lines.

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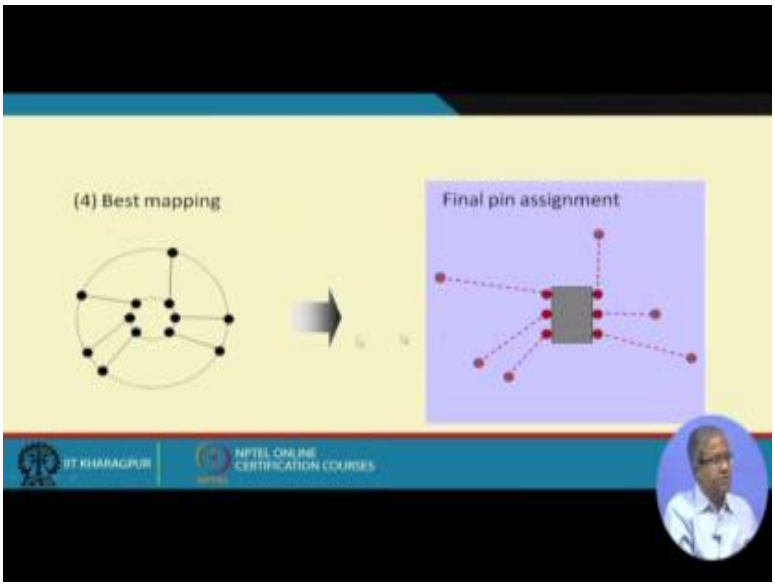

So, now you know, with respect to your chip. Now you replace them by your external pins again. Your 6 pins where there. Now on the concentric circles your positions have been fixed. Now you connect the corresponding pins to the corresponding points. This will be your best mapping. So if this means that by rotating the circle your original pin which was here as come here you make it here, no problem. That will be better solution. So just you allow the rotations, you make the best configuration then again you come back to the original one, that how the pins were connected there. Then you see that where the pin locations are coming so from there you connect to the external points which are there. That will be your final pin positions. This is the basic idea behind the so called concentric circle pin assignment algorithm.

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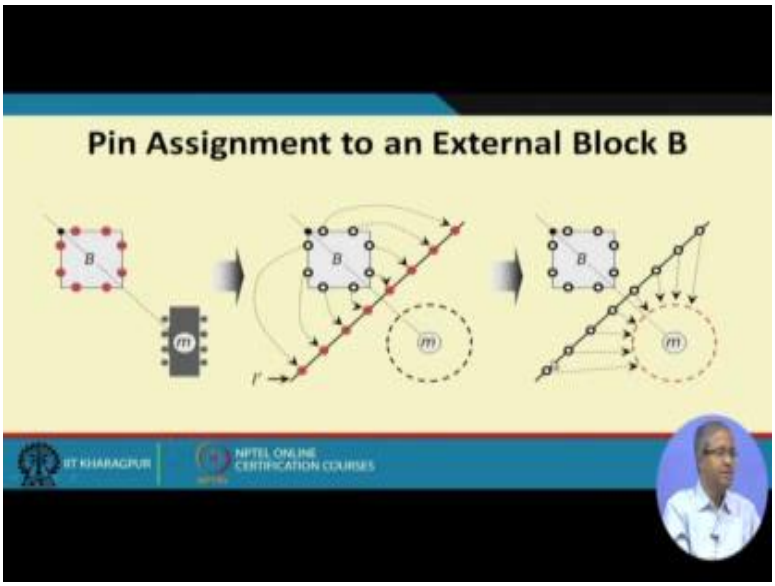

Now, if it is to an external block instead of several external pins, so this slide actually shows you illustrates you something on that. Suppose I am replacing a block here, there is an external block for which the pins are already been assigned. Here for this block you consider the imaginary circle like this, but you take another straight line for which you take the projections from these points, while I am shown it like this, this will all be straight lines. So for the projections with respect to the projections you find out the optimum angle of rotation of this inner circle. So you compute the cost and then you find out the optimum angle of rotation. So means roughly the idea I mentioned.

So, from the external block you project them in to a straight line by perpendicular you can say projections. And the block that you for which you do pin assignment, you again use a concentric circle make the rotations, such that with respect to the straight line the total length is minimised, get the optimum angle of rotation that will be your final pin position. So this is how this method works.

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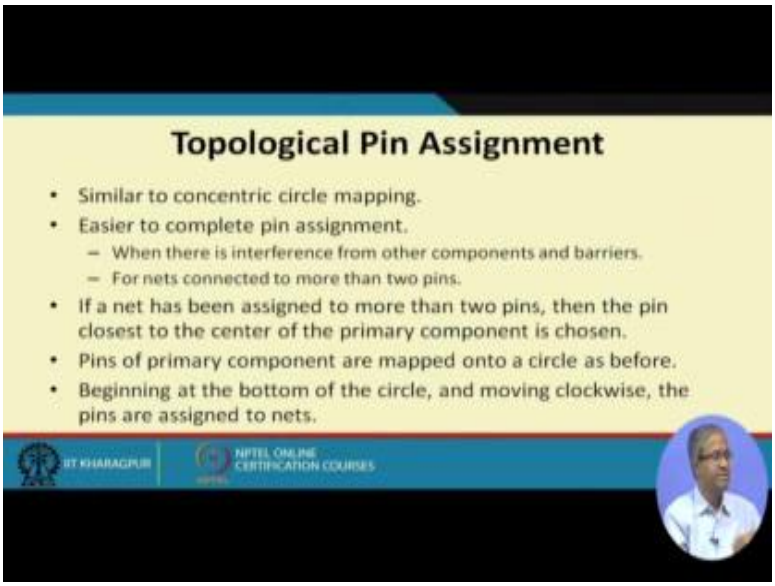

So, topological pin assignment is an alternate method which is quite similar to concentric circle mapping in. In fact, it is a little easier so here you can just handle nets which is assigned to more than 2 pins.

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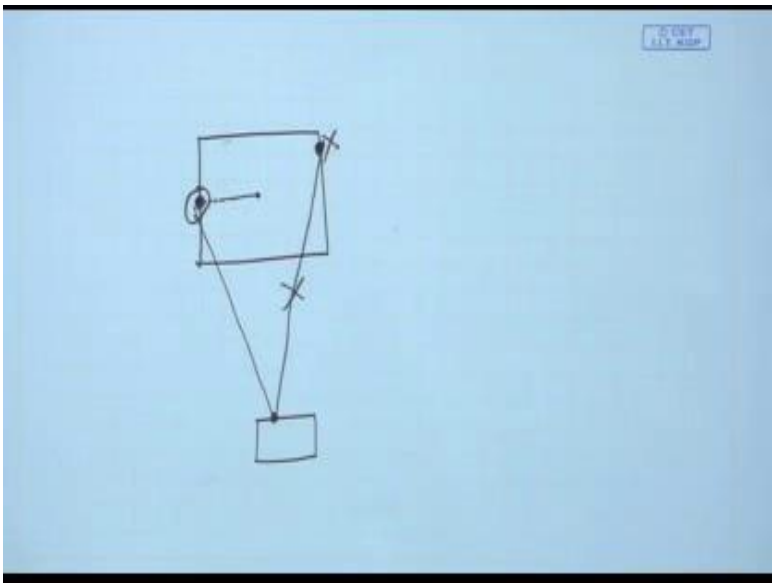

So, if it is like that in the pin which is closes to the centre of the primary component you take. Like that that I what I mean to say that, suppose there is a block where there are 2 pins, let say one pin is here and another pin is here. You see here and there is here a

block where you want to do pin assignment you have a connection here to make to both of them. You have connection to both of them.

You see for this block, this is the centre and this is the pin which is closer to this centre. So this is a little further. So you ignore this you consider this. You to forget this you consider this. This is what is mentioned. So the rest is quite similar.

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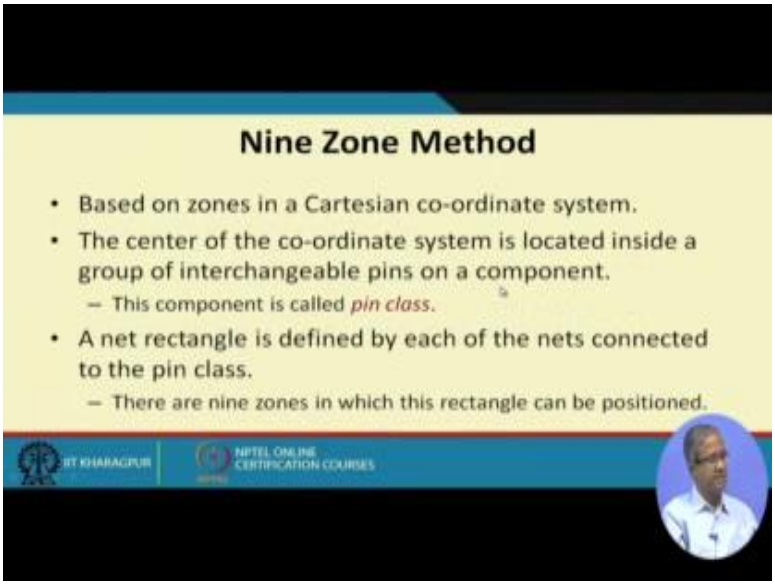

So, I am not going to detail of this. Nine Zone method is somewhat little different.

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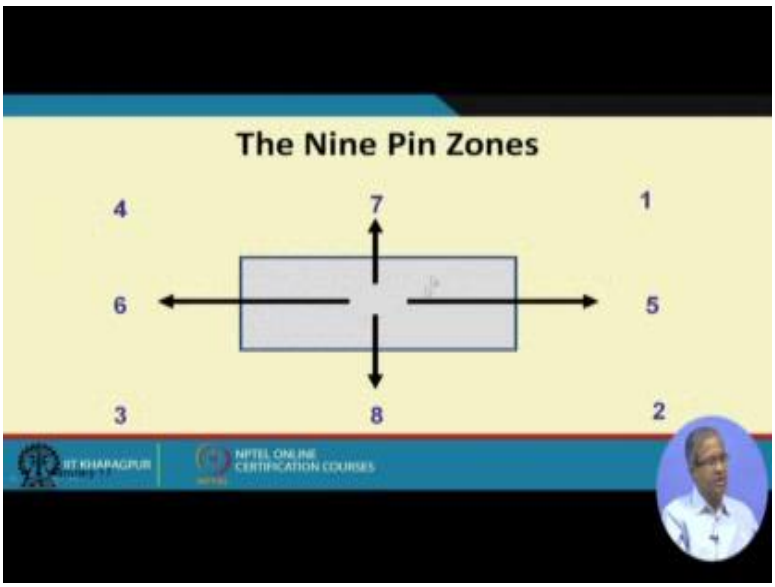

So, here I am just giving you the basic idea, here we are defining the entire rectangular zone around the block into 9 zones. We name them 1, 2, 3, 4. These are the diagonals 5, 6, 7, 8 are, the 4 horizontal and vertical directions. So whenever you have connection to be make external pins, you consider them with respect to the centre of this block. You see to which zone that connection belongs to. Like what I mean to say is that, let say you have this block you want to assign it is pins. So there can be may pins there can many pins.

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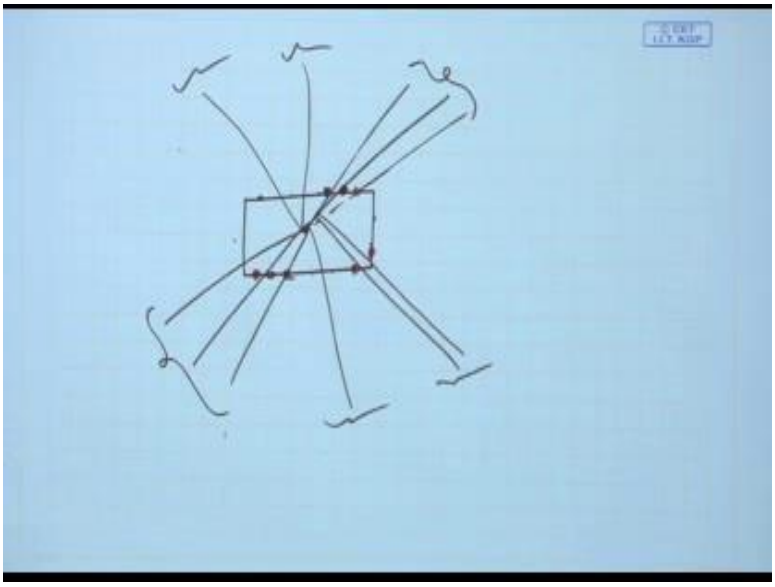

So, what I say is that, you consider this centre of this block. And if you consider the external pins from where connection have to made you look at them. So from where this pins are coming from. And then you try to group them into zones you can say that these 3 are falling into one zone, these 3 are falling into one zone, this is one zone, this is one zone, this is in one zone, this is one zone. May be maybe there is another in this zone. So you group these pins into zones. And zone wise you assign the pins. Suppose the pins which are belonging to this zone you take a projection, you assign them in this vicinity this 3 pins you assign to these vicinity. These 2 pins we assign to these vicinity, this 3 pins where assign to these vicinity, something like this.

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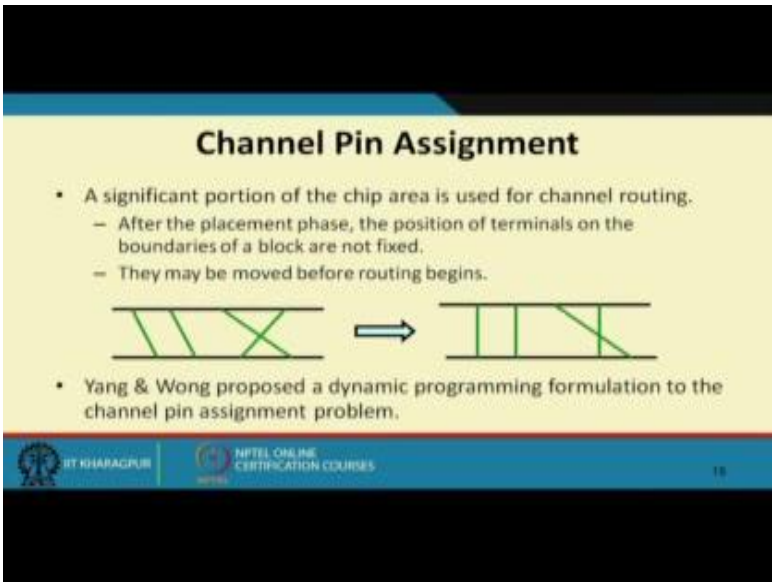

So, this is a heuristic method which works pretty well. This is a zone base method where you define the zones, and with respect to zones you do the assignment. Now this channel pin assignment is a special method which is applicable to standard cell based design.

So, this is one example I am trying to work it out and show you. What I am saying is that you can move some pins around, in this case you can move the blocks around such that you can make it vertical some of the lines, it save space. How it save space?

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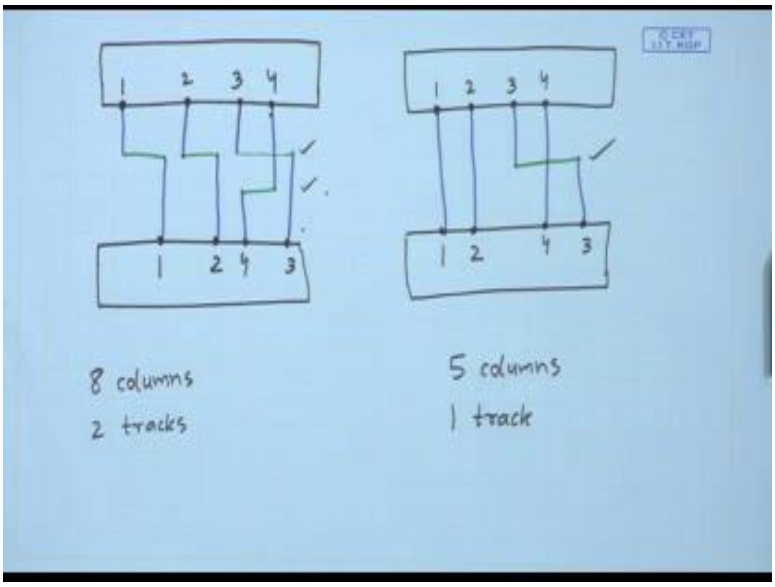

Let see. Let us take a channel problem. Let us say I have one standard cell row here one standard cell row here. And this is the routing problem let us say I want to connect the point 1 to a point 1 here. I want to connect the point 2 to a point 2 here. Similarly there is a point 3 here I want to connect it here, and there is a point let say 4 here I want to connect it here. So this actually is similar to the problem which is shown on this slide.

So, the connections have to be made like this, but in the actual real scenario, so how the words will be laid out? There will be laid out in 2 metal layers in horizontal and vertical I am showing you. Let us say one will be connected like this. This will be on one metal layer this will be on second method layer. Because all horizontal lines are typically on one metal, vertical line is on other metal. This will be on one layer, this will be on one layer, this will be on other layer. So for connecting 3 it will be like this, it will be like this, it will be like this. For a connecting 4 it will be like this, it will be like this, it will be like this. So you see, if you try to compute the area of this layout, so how many column are required in this layout - 1, 2, 3, 4, 5, 6, 7 and 8. 8 columns are required. And how many tracks 1 and 2. 2 tracks, but what I am saying is that by moving these blocks around, I can also move this pins around, so I can have a by moving them around.

So, I can have a scenario, where this pin 1 will be exactly a above this pin 1. Pin 2 will be exactly a above this pin 2. This pin 3 will be here of course, but pin 4 will again be exactly above one above the other. Now in this case how will be the lay out to wiring. This 1 and 1 can be connected directly on one metal layout. 2 and 2 can we connected directly. 4 and 4 can be connected directly. 3 can be connected like this. So using this what will be cost? Just if you similarly compute 1 2, 3, 4, 5; 5 columns and only one track. So you can see even in this simple, example if I am allowed to move this pins around here, and there so I can minimise the area that is required for my interconnection right.

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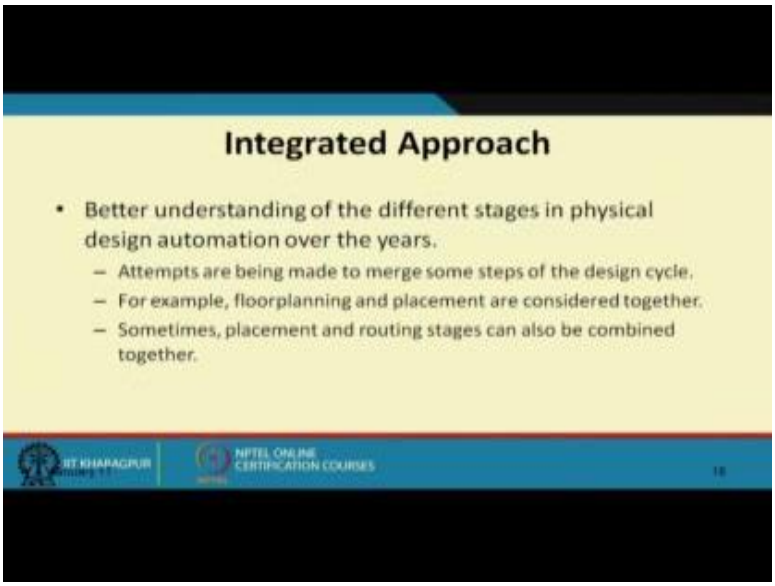

So, our integrated approach you can now think, where the various this floor planning this pin assignment you can merge them together, even the placement and the routing that will be consider link later on they can also be considered in an integrated way, so that you can have a holistic view of the whole problem. Like you can see floor panning and pin assignment if you consider them together may be you can get a better floor panning. So you can get better estimate of the wild links. There are lot of related issues. So this integrated approach basically talks about that. You can merge some of these steps floor planning placement can be merged, placement and routing can be merged, and so on. So with this we come to the end of this lecture.

Thank you.