VLSI Physical Design with Timing Analysis

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Week 05

Lecture 25

Floorplanning Representations

Welcome to the course on VLSI Physical Design with Timing Analysis. In this lecture, we will discuss about different representation of floor planning. So, here the content of this lecture includes how we can convert a floor plan into a different format. For example, from conversion of a floor plan into a constraint graph pair that the constraint graph pair can be of that horizontal constraint graph or vertical constraint graph. Then we will discuss about how to represent a floor plan using a sequence pair, then if you have a sequence pair given to us how can you generate a floor plan. So, this lecture will include all of these.

So, first of all we will discuss about the floor plan, how can the floor plan can be used to represent using a constraint pair graph. So, if you look into this one we have a given a floor plan with blocks A, B, C, D, E, F those are the blocks we need to create its constraint graph. So, there are basically two types of constraint graph is there, one is called the horizontal constraint graph HCG, then the second category is called the vertical constraint graph. We will discuss how we can generate a horizontal constraint graph and vertical constraint graph provided if you have given a floor plan of all the blocks.

So, the step first we will discuss about the horizontal constraint graph. The horizontal constraint graphs the first step of this process is basically is to create the nodes of A to F for the blocks A to F. So, each of the each of the blocks A will be translated to A nodes of the graph or vertices of the graph. A is denoted by A, similarly the B is denoted by the B like that I am giving one more example F is denoted by F. Now this is the first step, now we have to add two extra node which is one is called the source node and the termination node. This is the source node, and this is the termination node or the sink node. Then we will add edges, we will add directed edges, we will create a graph which is a directed graph. This horizontal constraint graph is a directed graph. So, then the question arises when we will add an edge. So, the question arises how when I can add an edge.

So, I have vertices vi, vj if mi is left of mj. So, we will add a edge from mi to mj if mi is left of mj. So, if you can see here your source node is left of A, source node is left of A. So, I should have A is from source node to A and every node is left of source node. So, that should be A is from source node to all the nodes. So, if mi is left of mj then we will have A is from mi to mj. Since source node is left of all of them then we should have edges from source node to all the nodes. Now we will have A is left of B so there will be A is from A to B. So, T is also left of A so there will be A is from A to T. So, we will do each node at a time. So, we will start with so we discuss about the condition of the directed edge then we will repeat the step for adding the edges for each node. So, first we will start with node S then A then B like that so on so till F node. So, this process will continue till all the nodes. So, how many nodes are there total? You have 1, 2, 3 then 4, 5, 6, 7 so this will be 7. So, all the edges are added here. Now after all the edges are added then we need to remove which is redundant. Redundant means that let us say I have A is from S to B but there is also a path from S to B through A so I should remove this edge. So, this is a redundant edge so we will remove that edge. So, the same process is repeated for all the cases then finally I will get a horizontal constraint graph. Now we will go into the vertical constraint graph.

In case of vertical constraint graph you have first step is to basically create the nodes of all the blocks. The first step is to create the nodes for each of the blocks. Block A has this one, block F is this one. So, all the blocks is represented as vertices. So, a graph has two things, one is vertices and edges. So, vertices are created using the blocks. And now we will look into how the edges will be added here. So, in case of vertical constraint graph your source node will be below the block and the termination node or the sink node is the above the block. In case of horizontal constraint graph your source node is left of the block and termination of the sink node is right of the block, right of the overall bounding box. So, but here if you can see it is on the below of the block source node and termination node is in the above the block. So, now we look into the how I can now I have all the nodes are created. Now I can look into how the edges will be created. So, I have to follow some rules. So, what is the rule here? So, it is also a directed graph. First it is a directed graph.

The second thing is that the A's will be added if mi is below mj, your source node is below all of them. So, that should be A's from source node to each one of them like this. So, now so the same process whatever it is done from the source node that process will be repeated for each of the nodes. So, I have to complete the process of adding the edges for all the nodes. So, for example node will start with S. Now I have added for all the nodes. After I did all the nodes then I will apply redundancy. So, what is the redundancy is that? Let us say I have a edge from S to A. But there is a path from S to C, C to A. So, I need to remove this edge. This is a redundant edge. So, we need to remove those edges. Now after I remove all the redundant edges this is my final vertical constraint graph. This is

my final vertical constraint graph. Now we look into the floor plan to the sequence pair. So, we have a blocks A and B are given to us. So, the location of the blocks are Xa. This is called the lower left corner. This is called LLX, LLY. Similarly, this is LLX, LLY. Lower left is LL. LL stands for lower left. So, this X the location or the location of block A and B is given to us, and dimension of the blocks are given. The dimension of block A is Wa is the width, Ha is the height, and the block B is Wb is the width, Hb is the height. So, after I have all this information I can write a constraint. So, if I have this is the condition then A is block A is left of block B.

So, if you can see here. So, this is my Xa, Ya. So, if my Xa plus Wa is less than Xb. So, if some block is sitting here. This coordinate will be what? Xa plus Wa. And what is this coordinate? This coordinate is Xb and Yb. So, the condition is that Xa plus Wa is less than equals to Xb. Then this block is, then A is left of B. And the second condition is that and Ya, Ya plus Ha means this point, this line. This line is Ya plus Ha because this height is Ha. Ya plus Ha. So, now that one should be less than equals to Yb. Or Yb plus Ha, Hb should be less than equals to Ya. If this is the condition that means that the block B is above A. So, we have to only look into A block is left of B. So, this the first condition should be satisfied and second condition should not be satisfied. So, that is why not. These two conditions together says that block A is left of block B. Similarly, we can do it for a block A is above block B using this expression. Same analysis can go. Now we will go discuss into the floor plan to a sequence pair. So, how can if a floor plan is given to us, how can you find out its sequence pair? So, basically, the floor plan is given to us.

The task is to generate the corresponding sequence pair. How we can do that? So, there are some of the notations you need to follow. Let us say you have first we consider the vertical constraint VCG. So, if your C block and D block and E block, if I draw a line here A is above C D E or C D E is below A. So, if that is the case, so we have to represent using two sequence. One sequence is S plus, and another sequence is S minus. So, there are two sequences there. So, the S plus we can write will come from the top to bottom. So, the first one is your A then the second one is your C then we will go to D then we go to E. So, this is for the S plus. Then what is for the S minus? Now I will go from bottom to the top. Let us say the C then after C I will see what is the below thing is there E then D then finally A. So, this is my sequence. Now this is done for C D E is below A. This is done then we will go for the other blocks. So, D E F if I look into this line and this line your B is above E F and D or D E F is below B. How can I write this sequence? I have two sequences: S plus. S plus whenever I am writing so I have already AC is there from the previous. Now I can write since I am doing the first sequence. So, I will go from the top to bottom B then D B then D then from E. Okay E then F. So, this is the sequence for the S plus. What is the sequence for S minus? S minus already C is there A is there will not touch those things other things will check actually. So, what is the sequence for D E F? Now for the D E F the sequence will be basically we will start from

bottom to the top E then F because both are in the same level. So, E F then you have D then B.

So, first I will go E then F then D then B. So, this is for D E F is below B. Okay I have two sequence. Now I will erase all of them. Now I look into one more block. What is that other block? I have basically this S plus S minus. So, here if I see AC is there in the earlier I am now worried about three block D E F other block all set. So, which are set I am writing in the red. Here also the C is there the first element is C. C I am writing first then B A is the last that is there. Now I look into how my D E F will be placed. So, if I am going by the same method I will come from the top. The top block is D here. D then E then F. So, this will be D E F and if I go from bottom to the top then I can go E F then D. So, now I have E F and D. Okay this is for vertical constraint graph. So, now what is the thing is that I have basically horizontal constraint graph. So, I have two sequence in case of horizontal constraint graph in the S plus sequence if my sequence is A B then S minus sequence my sequence will also be A B. Okay so if my A is left of B.

Okay so B should be placed after A. Okay so if A is left of B B should be placed after A but anything that should be there in between does not matter but the sequence should have B block after A that is the way the sequence will be made. So, first of all A is left of B. So, I have A and so we have taken the previous sequence here and we checking that whether it is satisfying or not if it is not satisfying will bring a some of the modifications. So, A is left of B so the first case it is satisfied A B is there A B is there so it is working properly there is no change. So, here if you follow this one so the previous sequence S1 is basically A B and S minus the sequence of A B is B A but to satisfy this constraint of the horizontal constraint graph this should be A B. So, we modified to A B from B A in case of vertical constraint graph. Now I have C is left of DEF. Okay your C block is the left of D E and F block. So, how can I represent that one my C should be left of DEF in S plus as well as S minus. So, if I go to the previous C should be left of DEF that is correct. Here C should be left of DEF that is also working correctly. So, there is no modification needed here. So, this sequence similarly you can check it for the E. After we do all this finally, we will get two sequence one is S plus is this one and S minus is this one.

This sequence pair is representing your floor plan. If I know this, I can create my floor plan and if I know the floor plan I can create this sequence. So, both are basically related. So, now if I have some information given to us, I can find the coordinates of the block so we will discuss that one. So, we need some more extra information. So, whenever you have a sequence pair to the floor plan what are those extra information are needed. So, one is the origin of the floor plan then the width and height of each block. Okay so and the packing direction. So, if these three things are there then if I have given a sequence pair I can create a floor plan. Okay so we discussed in the last slide if I have given a floor plan how to create a sequence pair but in this slide what we are doing if you have a sequence pair how to create a floor plan. For that one I need these three extra

information. So, basically in this case what we are doing is that, so we are creating a floor plan from the sequence pair. So, whenever I am creating a floor plan what are the things I need? I need the x y coordinate of each of the blocks. Okay so then the question arises how can I find my x y coordinate of each of the blocks. So, there will be one subroutine is there which is helpful to find the x coordinate and y coordinate. So, that subroutine is called longest common subsequence that is called LCS.

Okay so this LCS is the subroutine we will discuss that in subsequent slide. This LCS will find the x y coordinate. So, it will find the x and y coordinate for finding the x coordinate the input to the LCS is s plus s minus and width of each of the block. Okay it will give you the coordinate of each of the block. Then for finding the y coordinate the input to the subroutine is s plus reverse s minus and height of the block. If you can think little bit in depth width is helpful for finding the x coordinate and the height is helpful for finding the y coordinate. So, now this is the subroutine what we will discuss now. If we understood this algorithm or subroutine then it is basically easy to find the x y coordinate. So, there are if you look into this one it has basically three for loops are there. This is one for loop this is another for loop and inside there is a for loop. So, inside there is a for loop. So, the first one is the this first one is your initialization. It is used for initialization and the second for loop will run for number of blocks n is number of blocks n is number of blocks in the floor plan. Okay now we have to remember few of the variables here. Okay so some of the variables are for example you have block you have a block. So, you have a block order and a block. So, the block order is basically the position of the block in s2 sequence. So, what is s1 and s2? I can write it here your s1 corresponds to s plus s2 corresponds to s minus. Okay so which is input to your algorithm and weights are basically the width and height of the each of the block and output is basically the x and y coordinate of the blocks and total span of the L total span will be given by the L. So, now your block order will be determined by your s2 sequence. The initialization of all the lengths are 0 all the lengths are initially 0.

Now we will do one step at a time we will take one of the block at a time then it is processing the blocks and finally finds the total span of the block and if the span is greater than length then only your length is updated. If the test T span is greater than the length at jth node then the length of j is updated otherwise it will not updated. Okay so this is the very broad perspective of this algorithm it will be more clear if I go into the example here. So, I have a sequence pair to floor plan. So, how I am doing this one these are the things are given to me this is my s1 this is my s1 and this is my s2 correct. So, the packing direction is from left to down and floor plan origin is 0 0 then the each blocks dimension means that width and height of each of the blocks are given here. The task is basically find the x and y coordinate of all the blocks and finding the overall bounding box dimension. So, widths are given widths of block A is 8 and E is 4 height of A is 4 height of E is 6 which is given taken it from this information from this information then I

have s plus then I have s2 then I have since I am finding the x coordinate, so I am my weight is basically width okay. So, width of each of the blocks are taken. Then we look into the block order. What is this block order this is very important the block order is basically telling the position of the block in s2 okay.

It tells the position of the block in s2 okay. Let us see here so the block order so the block order of A B C D E is basically position of A first I will tell the position of A. So, this is position of 1 2 3 4 5 position of A is 3 position of B is 5 position of C is 1 position of D is 2 and position of E is 4. So, this is our block order which is found from s2 and initially all the lengths are 0 because we have not find the length of the overall block initially it is 0. So, this is solving this first step only this initialization step is done here. Now we will go to the iteration 1. So, here we need to find the position of A okay. So, the position of A okay is basically length of 3 okay. So, this block is A and index is taken from the block order. So, if you can see here index is basically block order of that block. So, here the block A index is 3 why I am taking the block A because in s1 the first block is A and this is basically block order of A which is 3.

Now the position of A is basically length of 3 okay which is 0 length is initially all 0 so it is 0. Then the T span is basically the position of A plus width of A this is basically the width of A. What is the width of A? You take here width of A is 8 here. So, 8 will be substituted here. So, now this is the T span. So, the length or now lengths are now updated after the index 3 till 5 all as 8. So, which is given here. Since my T span is greater than my length of j so the length of j is becomes the T span. Now we will consider the block C in the iteration 2. Why block C? Because block C is the second element in S plus. Now the index of C is basically the block order of C. The block order of C if you go here block order of C is basically 1. So, the block order of C is 1. Now the position of C is length of 1 is initially 0 initial value of this one is 0. Now the T span will be position of C plus width of the C. The position of C is 0 and the width of C is basically 4 and it is 4. So, since it is your 4 is basically less than 8, 4 is less than 8 so it will not update after 2. So, if you go here your T span should be greater than then only it will update otherwise it will break. So, 4 is less than 8 so it will not update after 2.

So, there will be two zeros are there that will be updated to 4. Similarly, you can proceed. Similarly you can proceed for the block D and block B and this is for the block E. After we do all these then the positions are providing the information for the x coordinate. So, the block E is basically 8, x coordinate of block E is 8 and x coordinate of D is 4 and B is 8 like that. So, the position of the block will give you the x coordinate. So, summary the position of the block gives the x coordinate of the block. Now the width of the block will be found by the T span. The T span what is the maximum width of the block will be given by the T span because I am just working in the x direction. So, now I am interested for the y coordinate. While finding the y coordinate only one thing will change my S1 will be represented by S1R. Basically reverse order of S1 will work. So, we have to work

for E block first. So, we have to work in this order E then B then D then C then A. So, this is my S1, my S2 will be the as the before is basically C, D, A, E, B. So, if that is the case my block order will not change. My block order will not change will be remain as it is because the block order is determined by S2. The block order is determined by the S2. If you see here the block order here is 3 5 1 2 4 here the block order is also 3 5 1 2 4 block order remains the same because it is determined by S2. Now the lengths are initially all 0. Now we will process the block E first. What is the index of block E? Index of block E is basically if you can see here index of block E is basically 4. So, I will take the 4. Now position of E is basically length of 4 is 0. Then the T span will be position of E plus height of E. The height of E will be given here. Height of E is basically 6 here. So, 6 will be added here. My T span will be 6. Since index is 4 my length will be updated 4 and above. It will increase from index equals to 4 to basically n. n here is the 5 number of blocks. So, this will be 6 and 6. Similarly if I go to the block B the index of block B is basically if I look into the index of block B is basically 5. Block B is 5 here. Now the position of B the position of B is length of 5 is 6 here. Now my T span will be T span will be the position of B plus height of height of B. If I look into the height of B is basically 3. Now the height of B is 6 plus 3 is 9. So, my that index 5 since the index is changing from 5 to 5 so only the 5 to 5 only the last index will change last value will change.

So, that will be 9. Similarly, 3, 4 and 5th iteration we can worked out there will be 3 iteration 4 then iteration 5 we have to worked out to find all the coordinate of the block A, B, C, D, E. So, these are the y coordinate of the blocks and the height of the block is basically determined by the T span which is given by length of 5 which is your 9 here. So, we now have all the information height and width of the global bounding box we know the x and y coordinate of all the blocks. So, the floor plan size is basically width is this much width is 12 and height is 9 and the coordinates of block A is 0, 5. Coordinate of block B is 8, 6. Coordinate of block C is 0, 0. Coordinate of block D is 4, 0. Coordinate of E is 8, 0. So, this is the floor plan if you can see the 0, 0 is your coordinate of C and coordinate of A is 0, 5 and the B is basically 8, 6. This direction is 8, height is 6. Then you have D 4, 0. Now this E is 8, 0. So, this is my floor plan. Width is basically my 12 and height is basically 9. So, this is the final floor plan. So, we discussed about floor plan representation and horizontal constraint graph, vertical constraint graph in detail in this lecture.

Thank you for your attention. Thank you.