VLSI Physical Design with Timing Analysis

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Week 05

Lecture 26

Floorplanning Algorithms - 1

Welcome to the course on VLSI Physical Design with Timing Analysis. In this lecture, we will discuss about floor planning algorithms. So, the content of this lecture includes floor plan algorithm and how we can do the floor plan sizing. So, the floor plan sizing determines the minimum area of the floor plan. So, your floor plan algorithm, it finds the minimum area of your floor plan and associated orientation of the and dimension of each block, how the blocks and the blocks orientation should be placed in the silicon such that my total floor plan area should be as minimum as possible. So, we have basically the cluster growth and simulated annealing algorithm which is use the netlist of the interconnection between the blocks and what it does is basically minimizes the total interconnect length. This is the goal actually minimize the total interconnect length. What is the constraint is that we have to have an upper bound on the floor plan area. So, our upper bound is that the floor plan area should be given as a constraint. We can also optimize jointly the wire length and area together.

So, these are the main focus of your floor plan algorithm. So, what it finds actually basically whenever I am doing floor plan sizing, it finds the dimension of the minimum area floor plan and it also finds the dimension of its individual block and its orientation of the individual block. So, this floor plan sizing algorithm uses the shapes of individual blocks and the top-level floor plan to minimize the total area of the floor plan. So, we have individual blocks dimensions are given which is used to minimize the total area of the floor plan. So, there is a shape function and corner points which is used to determine the optimal floor plan. So, what is this shape functions and corner points? So, let us say I have a block with area is given, area of the block is given. I have also given the width and height of the block. So, the width and height of the block is given, and the area of the block is given. So, basically there should not be any wastage of area inside the floor plan, but it is not always possible that there should not be any wastage. There might be some wastage in the whenever you place the block.

We will see that how some wastage is there and here you have area, area should be equals to w of the block multiplied by height of the block. But the area of the floor plan can be greater than this, but this is the lower bound on that. So, the area of the block should be less than equals to w block into h block. h block of the w is basically area of the block by w. You can keep the area same, but you have multiple possible combination of w and h. So, it is saying that you can have multiple possible combination of w and h which can give me the same area. So, that is possible, but in case of VLSI physical design, it is not possible to create any shape of the block. So, this shape function is important. So, what is the shape function is that if w and x means this line says that the area of the block is same at each of the points either w decreases, h increases, but area of my block remain the same. So, this one is the boundary of the area.

Anything above this one is allowed. So, we have two things. Let us say if my x is negative and y is negative, my area is positive because your area is width multiplied by the height. But this quadrant is not considered. The third quadrant is not considered because my width and height of the block cannot be negative. So, we have to discard this. This is not a feasible solution. This is not a feasible solution space. So, we only need to consider the first quadrant. So, we only need to consider the first quadrant. So, now, what are the points there? So, these are the points of my boundary. All the points in this one, all the points in this line satisfy my area constraint area equal to w block into h block. So, everything above this one is a legal area or a feasible region. All the values above this curve are legal or feasible region of my optimization algorithm. So, I need to find out any point above this one. Below is not allowed. So, this is the legal shape or the feasible area for the blocks. So, there is some bound is there. Whenever I am implementing any block, there should be some lower bound on the width, that should be some lower bound on the height. So, the lower bound means some blocks cannot be implemented in very small area. So, that is why what happens is that I have to find out some lower bound in the x axis and lower bound in the y axis. So, such that these areas are not allowed. This area is not a legal area. So, rest of the things, this is a legal area, legal region. So, now my shapes of my shape function is now comes out to be this much. Now this is because of some lower bound in the shape of your design. Then there is some technology dependent design rules are there. You have some technology-dependent design rules are there. In that case what is happening that we can create shape of the block in some particular positions, not like a continuous function of w and h, w and h pair. So, those restricted points are the feasible area.

These are the feasible area of your design, and these are represented using a discrete value. So, let us say I have a block, it can have some possible shape but not a continuous value of w and h, combination is not allowed. Only some discrete values of w and h which will give me that same amount of area is allowed. And there are also some hard IPs are there. Hard IP is like you have some memory block or some third-party IP, memory generated from memory compiler or third-party IPs. So, those blocks have only two orientations. Why two orientation? It can be laid out, let us say my lock can be like this. This is my w, this is my h, this is one possible combination, one orientation or I can put it horizontally, little not up to the, this is my h, same as the previous one, this is my w. So, there are two possible points are there in my shape function for the hard IP. Now we will look into some of the blocks how I can use to create my floor plan. So, let us say I have this discrete dimension of the block can be thought of non-dominated corner points that limits the shape function. So, here if you can see I have two orientation, one is horizontal orientation, one is vertical orientation. So, this width is basically 1 and height is 3. So, this block is find a point in the shape function. And the second block, this horizontal orientation will give me this point where my width is 3 and my height is 1.

Ok, width is 3 and height is 1 that will give me my second orientation of the block. There are two points in my shape function. So, now we will discuss how to find a minimum area of our floor plan. So, basically it has few of the steps, three major steps are we have to construct the shape function of each of the blocks. The number of blocks in your floor plan each of the block you find the shape function. Determine the shape function of the top-level floor plan from the individual blocks using bottom-up strategy. From the corner point that corresponds to the minimum floor plan area, trace the top-down fashion to back to the block shape function to find the blocks dimension and location. So, the finally what we need to do is that we need to find the each of the blocks dimension and location to find the basically floor plan area. So, finally what you have to do is that the corner points that corresponds to the minimum top level floor plan area that is used to find the blocks dimension and location of each of the block. So, let us take an example. It will be more clear with an example whatever I am discussing in words.

So, what is the here the I have two blocks block A and block B and dimension of the blocks are given. So, the block A has two orientation or two dimensions. This is the first dimension, and this is the second dimension. It can be placed vertically it can be placed horizontally. So, this is the two dimensions then the block B has also two dimensions one is this and one is this and so these are the two blocks. So, what is the task here is to find the minimum floor plan area using the both vertical and horizontal composition and its corresponding slicing tree to create its corresponding slicing tree. So, first of all we will take the block A and find its shape function. The block A has two points in so it has one point width is 3 width is x axis here width and y axis here height, so width is 3 here and height of the block is 1 here. So, this point finds a point in your shape function. And if you look into this orientation of the block the width of the block is 1 here which corresponds to this one then we have 3 which corresponds to this one. Now I got a point this point in my shape function. Now I have two points discrete points in my shape function. So, these are the two discrete point in the shape function of the block A in the shape function of block A. Now I have a block B which is having two orientations so the width is basically this much 4 and the height is 2. So, this is a point in the shape function of the block B.

I have this is a point in the shape function of block another orientation of the block B. So, finally these two are my shape function of block B. I have two blocks block A and block B both shape functions I have found out. Now I have to construct the basically. My final goal is to find a minimum area floor plan. So, I plot both of them together in the same graph. So, now I have block A and block B. So, if I add both of them so here I am doing vertical composition here I am doing the vertical composition one above the other. So, if I do that so here the height is basically 3 here and here the height is 4 here. So, if I put one above the other the height of the overall floor plan will be 3 plus 4 is 7 it will come somewhere here. So, this is the height of my overall floor plan. Similarly, this is one point of the shape function. Similarly, if I go for the other points so now, I have another possible floor plan is that this height is 1 and other height is basically this from this height is 4 so it will be 1 plus 4 is 5. So, this is a possible solution. Now this height is 1 for block A and the height of B is basically 2 so from the below to here. So, 1 plus 2 is basically 3. So, I have 3 different floor plan for this block A and B. So, the first one is having 7 cross 2 basically the floor plan area is 14 and the second one is 3 cross 4 is 12 and the third one is 5 cross 3 is 15. So, if you can look into the vertical composition this one is the best composition which is giving 3 cross 4 is 12 is the minimum area. So, this is the best composition if I take the blocks in the vertical direction. So, in this slide we will discuss about the horizontal composition of the floor plan. So, what is given to us the shape function of the block A and shape function of the block B is given to us.

The shape function of the block A is this one and shape function of the block B is the other one this one. Now what we are doing is that we want to find out the what is the shape function of the horizontal composition of the floor plan. So, what we are doing here is that we have to keep the blocks side by side in case of horizontal composition. So, we are finding the shape function of the overall horizontal composition. So, here what we are doing is that we are taking a point of this one which is having the width of 1 and we are taking a point of this one which is having a width of 2 then the feasible point in the horizontal composition of the floor plan will have a feasible point whose value will be 3. So, this is a feasible point of the shape function of a horizontal composition of the floor plan. Similarly, we can find for other feasible points. So, this is one feasible point whose value is 5 and we have another feasible point whose value is 7. So, all these are the feasible point of the shape function of the horizontal composition. So, these are the feasible solution for the floor plan. So, if you can see here, we have three solutions are there and the area of each of the solutions are different. So, this point corresponds to this floor plan because if you can see here the width is basically width of the floor plan is 3 and height of the floor plan is 4 here, width is 3 here and height is 4. So, this is corresponding to that floor plan. Similarly, and similarly this point will have width of 5 and height of 3. So, this corresponds to this floor plan. So, you can see width is 5 here and height is 3 here and then you have basically another floor plan is there, this point is belongs to this floor plan. If you can see here width is 7 here and width is 7 here and the height of the floor plan is 2 here and the height of the floor plan is 2 here. So, we have three solutions to this horizontal composition and area of each of the compositions are different. So, we should look for the minimum area.

So, 12 is the minimum area. So, this is the optimal area floor plan. So, area of this floor plan is minimum. So, we choose this floor plan. So, we have basically two different approach, one is horizontal composition, one is vertical composition. We will choose the best from the horizontal composition, we will choose the best from the vertical composition, then among the two which is the best we will take that one as the our floor plan. So, in this case 3 cross 4 12 is the best in case of horizontal floor plan. Basically, if you can go back this is also this area is also best for vertical composition. So, either one of them can be chosen for our floor plan. So, this is my basically minimum floor plan area. There are multiple minimum floor plans are possibly the same area in this example. So, this is my floor plan and then the slicing floor plan for this one is basically V because of this line and you have left child is basically A and the right child is basically B. So, this is my slicing tree for the given floor plan. Okay, so this is all about how we can create a floor plan from the shape function. In this lecture we discussed about different types of floor planning algorithm and what is the objective of the floor planning algorithm. Then we discussed about how to create a shape function of the individual blocks in a floor plan and the shape function is useful for creating the minimum area floor plan.

Thank you for your attention. Thank you.