Design Credit Report

Automatic wire Routing under Constraints

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Abstract

- This project is about to perform the routing of a group of signals to a target block of the design in such a manner that a given congestion limit is obeyed and the routing is completed within a fixed wire length budget.
- One of the secondary objectives can be minimization of wire-length.
- Moreover, the goal also is to identify signals (out of the bunch of identified signals) which can not be routed to the target block within the specified congestion and wire-length limit.
- Total length of wires within the specified congestion and wire-length limit .

Introduction

- Wire routing congestion occurs on a system-on-chip when a lot of wires (or metal lines) are routed in a narrow space. It becomes prevalent in the on-chip interconnect fabric because it must be routed in the floorplan "white space" between IP block restrictions.
- Connect the various standard cells using wires.
- The Objective of the project is to minimize the total wire length , minimize running time , minimize the total overflow .
- Input: Cell locations, netlist
- Output: Geometric layout of each net connecting various standard cells
- Two-step process :

  1 .Global routing

  2. Detailed routing

Design Problem Formulation

- When few signals are selected for routing to a target block , the routing of these signals needs to take care of the existing routing congestion .
- In some of the previous work , routing algorithms are based on reducing the half-perimeter wire length , measured during Manhattan distance , which is agnostic of the existing routing congestion .
- Moreover , the congestion caused by the initial signal routing needs to be considered for the purpose of final routing of all the desired signals to the target block.

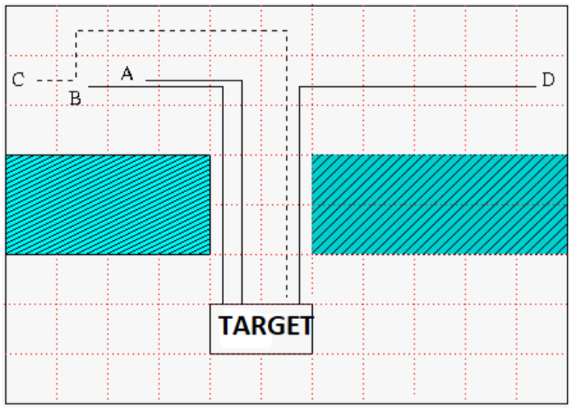

Figure 1: Constrained Signal Routing Example

- As shown in the figure-1 which is utilized to elaborately explain the problem statement We have divided the entire layout area (G) into smaller grids, with the restriction that at most two wires can pass through each grid.
- The congestion areas are shaded. Let us assume that A and B are the first two signals to be routed to the target block.
- These two signals are traced without any difficulty in routing. Suppose, it is given that the choice for the next signal is either C or D.
- As can be seen from Fig. 1, the Manhattan distance of C is lower than D. However, due to the congestion introduced by wires A and B, the wire length required to route signal C is more than that of D.
- Therefore, merely assuming the magnitude of Manhattan distance for routing impact estimation of the signals is not very useful.

Methodology Adopted for the Problem

- After discussing possible methods to solve the problem we chose the algorithm named

the proposed congestion aware algorithm .

- The proposed layout wire length measurement technique takes into consideration the routing congestion introduced by the successive signals getting routed.
- The proposed signal routing wire length measurement technique is based on Lee's algorithm.
- Before routing the signals, the current congestion criteria of the design is updated (i.e., layout regions unavailable for routing are recorded and tracked).
- To avoid routing congestion, we consider a factor Wlimit (typically as 3 or 4) as the maximum lines allowable through the smaller rectangular grids in G (which represents the complete layout area).
- Collision detection is done by checking if a (smaller rectangular) grid on the path g has G[g] equal to Wlimit. In cases where Wlimit has been already reached, the algorithm attempts rerouting by moving it up/down and sideways.
- For example, if the grid [3,4] is filled, an attempt is made to route through [3,3], then move right and so on.
- Consider the distance of any signal from the "Target" block as n and Max(n) is the Maximum Manhattan Distance of all the candidate signals. Consequently, for each signal, Froute can be defined as below since it is not beneficial to route chains (which are the connections from the signal to the "Target" block) with length more than the maximum Manhattan distance, Max(n).

$$F_{route} = \begin{cases} 1 & \text{if n<Max(n)} \\ 0 & \text{if n>Max(n)} \end{cases}$$

- This function ensures that the signals are getting routed by Manhattan distance when there is no congestion.1 In the proposed algorithm, congestion avoidance takes place only when there is routing congestion and thus Manhattan distance based routing wire length can not be allowed in this case.
- Consider that "N" is the total number of signals to be routed to the Target block.
- The following code shows a pseudocode of our algorithm.

for *each signal* ff_i *in* N **do**

  ffx, $ffy \leftarrow$ coordinates of ff_i from *placed Coord*;

  $Value$=$F_{route}(ff_i)$;

  If $Value$=1, proceed below else skip to next signal;

  For each grid g belonging to G that has a wire routed through it, G[g] = G[g]+1;

  Across G, move above, below, sideways (from east to west and then from north to south) and check for $Wlimit$ in each direction;

  Obtain wire length(wl) from ffx, ffy and *tbx*, *tby*;

  if *G[g] != Wlimit && wl* $<$ *maxlength* **then**

    Signal can be routed to Target block;

    Update G for smaller grids in this path to Target block;

  end

  else

    Signal can not be routed to Target block;

  end

  Wlength $\leftarrow$ *wl* of routed signal;

end

routed Conn $\leftarrow$ routed connections of signals;

Justification of the design choices

- The proposed layout wire length measurement technique takes into consideration the routing congestion introduced by the successive signals getting routed.
- Before routing the signals, the current congestion criteria of the design is updated (i.e., layout regions unavailable for routing are recorded and tracked).
- That’s our algorithm takes less runtime and less number of variables.
- Algorithm takes less time for a very large number of inputs and optimize solution of complex problem like routing.
- This algorithm is effective and efficient which is an essential condition to handle the challenges arising from the fast growing scaling of IC integration.

Results and Analysis

- Routed connection between input signal and target block [(300,300)] in a grid of 301 x 301
- Routing wire lengths such that given congestion limit , which was considered as 3 is obeyed .
- identification of some signals which can't be routed within specified congestion considered as 3 .
- Total sum of routing wire length is 3866 units .
- Runtime of code is 1.174 seconds .
- Algorithm works the best for the routing of group signals to The target block with constraint of congestion limit (3) obeyed and Routing is completed within a fixed wire length budget.

```
Total wire length under the congestion limit considered as 3 is 3866

[Done] exited with code=0 in 1.174 seconds
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Conclusion

- Routing is one of the most fundamental steps in the physical design flow and is a typically very complex optimization problem.
- Effective and efficient routing algorithms are essential to handle the challenges arising from the fast growing scaling of IC integration.
- Our Algorithm works the best for the routing of group signals to The target block with constraint of congestion limit (3) obeyed and Routing is completed within a fixed wire length budget.
- Signal identification has been done through the algorithm that can't be routed to the destination due to congestion.

References

- http://iccad-contest.org/2021/Problems/Problam_B_20210220_1540.pdf
- https://docs.google.com/presentation/d/1_dqX9vGL4PdAY4HrRCtb7jCAHp_YeUe-/edit#slide=id.p1