Correspondence on 'Planar constrained terminals over-the-cell router'

J.-T. Yan

Indexing terms: Over-the-cell routing, Constrained terminal

Abstract: A new routing model with constrained terminal structure for over-the-cell channel routing and a graph theoretical algorithm for solving the planar constrained terminals over-the-cell routing problem have recently been published. The routing model with constrained terminal structure assigns the connection constraint between adjacent layers on terminals and makes use of the vacant locations on each layer for over-the-cell routing. Based on the constrained terminal structure, a graph theoretical algorithm is proposed to complete planer routing layer by layer for over-the-cell channel routing. The new routing model and the graph theoretical algorithm are shown to be flawed, and corrections are suggested.

1 Correction of flawed routing model and algorithm

This short paper concerns a recent paper by Shew and Hsiao [1] which proposed a new routing model with constrained terminal structure, and developed a graph theoretical algorithm for solving the planar constrained terminals over-the-cell (OTC) routing problem. Basically, the routing model is similar to the traditional HCVD model [2]. The main difference between the new model and HCVD model is the way nets are connected to standard cells at the terminal positions (see Figs. 2 and 3 in [1] for three-layer OTC routing). It is assumed that vias are not allowed and planar routing is constrained on the OTC area. For channel routing, an HVHV routing model using polysilicon, M1, M2 and M3 layers is adopted. Based on the constrained terminal structure, a graph theoretical algorithm (see Fig. 8 in [1]) is proposed to complete planer routing layer by layer for over-the-cell channel routing.

For correction of this flawed routing model, based on the definition of the HCVD model [2], feedthroughs are assigned on the M1 layer, cell terminals are assigned on the M2 layer, and only the M2 layer is used to route the OTC region for two-layer OTC routing. Furthermore, for n-layer OTC routing ($n > 2$), feedthroughs are assigned on the M1 layer, cell terminals are assigned on the M2, M3, ..., Mn layer, and M2, M3, ..., Mn layers are used to route the OTC region. In the published routing model [1], the structure of the cell terminal is constructed by one vertical column of terminals from the M1 layer to the Mi layer if one net is routed over the cells on the Mi layer, and the terminals from the M(i + 1) layer to the Mn layer are used as vacant terminals for routing the other nets over the cells. Since feedthroughs are assigned on the M1 layer in the HCVD model, the published routing model is flawed and the correction is that the structure of the terminal is constructed using one vertical column of terminals from the M2 layer to the Mi layer if one net is routed over the cells on the Mi layer. Clearly, three structures of constrained terminals for 4-layer OTC routing are possible, as shown in Fig. 1.

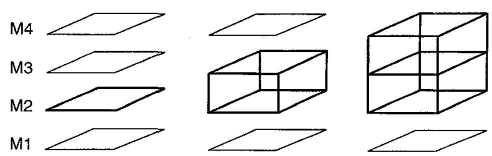

Fig. 1 *Three possible structures of constrained terminals for 4-layer OTC routing*

Concerning correction of the flawed routing algorithm (as a result of the flaw in the constrained terminal model and the HVH routing model in the channel region), there are two main errors in the published graph theoretical algorithm [1]. First, based on the corrected constrained terminal model, it is known that the M1 layer is not used to route over the cells. Therefore, the loop statement 'FOR layer ← 1 TO MAXLAYER DO' is replaced by the statement 'FOR layer ← 2 TO MAXLAYER DO'. On the other hand, based on the definition of the HCVD model and the HVH routing model in n-layer OTC routing, horizontal trunks are routed on the M1, M3, M5, ... layers and vertical branches are routed on the M2, M4, M6, ... layers in the channel region. For n-layer OTC routing, the structure of the terminal in the net is composed of one vertical column of cell terminals from the M2 layer to the Mi layer if one net is routed over the cells on the Mi layer. Only the upside terminals on the even layers are used as vacant terminals for routing the other nets over the cells. Therefore, the statement 'Candidates ← FindCandidate()' is replaced by 'Candidates ← FindCandidate(*layer*)'. In FindCandidate(*layer*), the upside terminals are considered as vacant terminals in the M*layer* layer if *layer* is even, and further candidates for planar routing will be found. In contrast, the upside terminals will not be considered as vacant terminals in

IEE Proceedings online no. 19982096

Paper first received 14 August 1997 and in revised form 26 March 1998

The author is with Microelectronics & Information Systems Research Center, National Chiao Tung University, Hsinchu, Taiwan

the M*layer* layer if *layer* is odd, and candidates for planar routing will be found. Therefore, the published graph theoretical algorithm [1] is corrected as shown below.

Algorithm PCTOTC

FOR *layer* $\leftarrow$ 2 TO MAXLAYER DO

BEGIN

  Candidates $\leftarrow$ FindCandidate(*layer*);

  AssignWeight(Candidates);

  tmp $\leftarrow$ MWICS($S_{TOP} \cup S_{II}$);

  S_1 tmp $\cup$ MWICS(($S_{BOT} \cup S_{II}) \ominus$ tmp);

  tmp $\leftarrow$ MWICS($S_{BOT} \cup S_{II}$);

  $S_2 \leftarrow$ tmp $\cup$ MWICS(($S_{TOP} \cup S_{II}) \ominus$ tmp);

  IF W(S_1) > W(S_2) THEN S[*layer*] $\leftarrow S_1$

  ELSE S[*layer*] $\leftarrow S_2$

  PlanarRoute(S[*layer*]);

  RouteFreeCandidates(S[*layer*]);

  UpdateGraph();

END

2 References

1 SHEW, P.W., and HSIAO, P.Y.: 'Planar constrained terminals over-the-cell router', *IEE Proc. Comput. Digit. Tech.*, 1997, **144**, (2), pp. 121–126

2 CONG, J., PREAS, B., and LIU, C.L.: 'General models and algorithms for over-the-cell routing in standard cell design', *IEEE Trans. Comput.-Aided Des. Integr. Circuits Syst.*, 1993, **12**, (5), pp. 723–734